WATER TABLE. STUDY FOR

NITRATE MANAGEMENT AND IMPROVED 'SITE EVALUATION

FOR WASTEWATER TREATMENT

Subsurface Site Hydrology As It Pertains
To Wastewater Treatment and Disposal in Virginia
Grant #NA870Z0253-01

Submitted by

Carl D. Peacock, Jr.
Jay F. Conta
Philip R. Cobb
Gary F. Whitley

Prepared for

Virginia Department of Enviromental Quality
Virginia Coastal Resources Management Program

National Oceanic and Atmospheric Administration
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INTRODUCTION

In obtaining this research project, the Virginia Department of Health noted it currently faces both goals and barriers in its oversite of the onsite wastewater program. Goals included: 1) to more thoroughly evaluate hydrologic factors in siting and designing wastewater disposal systems to minimize impacts on surface and groundwater; 2) to better understand shallow seasonal water tables to establish appropriate separation distances between septic systems and the seasonal water tables; and 3) to better understand the role of soil and site characteristics related to the potential transport of pathogens and nutrients from septic systems, in order to target areas of greatest pollution susceptibility.

The research proposal also noted two barriers it faces in trying to achieve those goals: 1) a lack of information concerning seasonal water table behavior; and 2) a lack of soil hydrologic training for VDH staff working in the onsite wastewater program.

This research project attempted to characterize selected soils from across Virginia as to their seasonal water table and soil morphologic features. In some cases, the studies confirmed accepted beliefs about soil features and duration of saturation, while in other situations it was demonstrated that there are additional seasonal water indicators that are not universally accepted.

This report was 41.4% funded, by the Virginia Coastal Resources Management Program at the Department of Environmental Quality through Grant #NA87OZ0253-01 of the National Oceanic and Atmospheric Administration, Office of Ocean and Coastal Resources Management, under the Coastal Zone Management Act of 1972, as amended.

METHODS AND MATERIALS

Research sites were selected in Coastal Zone counties with a few sites in western Virginia. The soil sites selected had a broad array of features and properties. The number and type of monitoring wells installed at each site was determined based on soil characteristics.

Devices that were programmable and would record the water table level automatically were purchased from Remote Data Sensing, Inc.** RDS automated data loggers were either WL-20 wells (recorded water tables up to

** The mention of trade names, products or companies in this report does not constitute an endorsement.

approximately 20 inches below the soil surface) or WL-40 wells (recorded water tables up to approximately 40 inches below the surface). WL-20 wells were typically used at sites where there was a shallow restrictive hodzon in the soil, so the perched water table could be studied. WL-40 wells were used to monitor soils with restrictive hodzons at greater depths or where an apparent water table (coming up from below) was to be studied. Data loggers were typically programmed to record the water table every 6 hours, but in some cases readings were made every 3 hours or every 12 hours.

In addition to using automated monitoring wells, some research sites utilized manual observation wells. The number of 'manual wells and their depth was determined by soil and site characteristics.

When a site was to be used as part of the study, a large diameter (4 inches) hole was bored by hand in the soil to a depth of either 24 or 48 inches, depending on whether a WL-20 or WL-40 well was to be installed. A small amount of clean pea gravel or coarse sand was poured into the bottom of the boring. Each data logger had a marking indicating the depth the well was to be set into the ground, so the amount of gravel or coarse sand used in the bottom of the hole was determined by that marking.. Once the well was established at the correct depth in the ground, pea gravel or coarse sand was added around the outside to the well casing. For WL-20 wells approximately 12-16 inches of pea gravel or coarse sand was added around the well casing; for WL-40 wells approximately 40 inches of pea gravel, or coarse, sand was added. Then 8-12 inches of bentonite grout was poured into the annular space and water added, to create a water-tight seal around the well casing. In some cases, the final few inches of the annular space were backfilled with excavated soil from the borehole.

When a manual observation well was to be installed, a large diameter (4 inches) hole was bored by hand in the soil to the desired depth. ^ small amount of clean pea gravel or coarse sand was poured into the bottom of the boring. Two,inch diameter PVC pipe was cut to the desired length and placed into the hole, with an open end resting on the pea gravel or coarse sand at the bottom of the hole. ^ threaded cap was screwed onto the top of the pipe to seal it off. Pea gravel or coarse sand was added around the outside of the well casing up to approximately 12 inches from the ground surface. Then 8-12 inches of bentonite grout was poured into the annular space and water added, to create a water-tight seal around the casing. In some cases, the final few inches of the annular space were backfilled with excavated soil from the borehole.

Once installed, data loggers were programmed following procedures outlined by RDS. At some sites, wells were camouflaged due to public access and the potential for vandalism.

Once installed, data logger sites were visited on a variable fequency, depending on the such variables as the number of daily water table readings taken, weather conditions, and the need to replace a well's battery.

'At some point after well installation, a detailed soil profile description was made at the research site. Soil descriptions were made from pits or auger bodngs. Descriptions were made adjacent to the wells. When there were several wells located at a site and they were remote from each other, then separate soil profile descriptions were made to characterize the soil adjacent to each of the separate wells. USDA-NRCS standard nomenclature and procedures were used in soil profile descriptions.

When data collection was underway, downloaded water table readings were processed using Microsoft Excel. Data were analyzed to determine the number of days the seasonal water table was in vadous depth ranges in the ground, and the cumulative number of days each soil depth was saturated.

While this was one research project, it should be noted that there were four individuals working independently on their research sites, in three physiographic provinces across the state. As a consequence, some minor differences in writing styles and anaylzatin of the results might be noted in the report. Phillip Cobb studied Faceville, Jackland, Kelly, Nason-like, and Penn soils. Jay Conta studied Emporia, Kinston, and Spotsylvania-like soils. Carl Peacock studied Ackwater, Acredale,~ Dogue,~ Dragston,..Lenoir, Munden,~ NimmO, and Yemassee soils. Gary Whitley studied Cotaco, Groseclose, Leaksville, McGary, and Zoar soils.

SOIL CONCLUSIONS AND REGULATORY RECOMMENDATIONS

ALTERNATE WATER TABLE INDICATORS:

Unmottled horizons (A,E, Bt1) had free water for only short periods of time during winter-spring periods. Sharp upward spikes of the water table into the unmottled horizons lasted a few hours to a few days during any given event This is based on data from the Ackwater, Cotaco, Dogue, Emporia, Leaksville, and Munden sites. In the case of one Emporia site, the unmottled Bt2 horizon had free water in it for several days to several weeks at a time and was probably unmottled due to saturated-aerobic conditions (due to rapid lateral water movement through the site).

Horizons with morphologic features (redoximorphic features) such as chroma 3 and 4 mottles, and yellowish red or strong brown mottles, had free water present for up to 3 months during the winter-spring periods. This is based on data from the Ackwater, Cotaco, Dogue, Emporia, Leaksville, and Munden sites.

especially benefit from local, customized, soil morphology training. This group of local staff has a high and personal interest in learning and sharing knowledge of the local soils. Small group training for the local VDH environmental staff will be provided.

Horizons with morphologic features (redoximorphic features) such as chroma 1 through 4 mottles and yellowish red and strong brown mottles, had free water present for up to 4 months dudng the winter-spring pedods. This is based on data from the Ackwater, Cotaco, Dogue, Leaksville, Munden, and Yemassee sites.

Gleyed hodzons with high chroma mottles (redoximorphic features) had free water present for more than 4 months during the winter-spring periods. This is based on data from the Acredale, Ackwater, Dogue, Dragston, Lenoir, Kinston, Nimmo, and Yemassee sites.

Excessive precipitation contributes to the presence of free water that may be shallower than the depth to redoximorphic features. This was evident in the Ackwater, Acredale, Dogue, Dragston, Lenoir, Nimmo, and Yemassee soils. In contrast to soils receiving excessive precipitation, numerous sites in the study had below normal rainfall. Free water at these sites was below horizons exhibiting soil wetness indicators. This is based on data from the Spotsylvania-like sites.

AFFECTS OF LANDSCAPE POSITION ON THE WATER TABLE:

Landscape position can have a strong impact on the amount of groundwater any given site might have. The Spotsylvania-like soil was nearly identical to the two Emporia soils studied, . but was located on a shoulder position. It never had any water in it. The Emporia soils (one on a lower sideslope; one on a broad upland landscape) had free water continuously present for 3-4 months.

Soils located on shoulder' positions or on a narrow summit will be significantly drier than the same soil located on lower sideslopes or on broad (ie, lacking good surface drainage) landscape positions. Implications are that soils which appear to have severe limitations for an onsite septic system due to shallow mottling and are located on shoulder or narrow summit positions, may have relic mottling and would be good candidates for a water table monitoring test to assess their true wetness.

Soils located in poor landscape positions (ie, lower sideslope or footslope with a long upslope watershed; broad uplands lacking good.surface drainage) may be wetter than their mottling might indicate. Soils with large upslope watersheds may be wetter than their mottling patterns might indicate. This was seen at one of the Emporia sites, and the Cotaco site.

RESTRICTIVE HORIZONS:

^ restrictive horizon is a horizon that impedes the movement of groundwater, especially downward. ^ restrictive horizon commonly has a perched water table above the restriction. ,The Virginia Sewage Handlin,q and Disposal Requlations

(2000) indicate that a restrictive horizon may be enough of a soil limitation to reject a site for a septic system drainfield. A percolation test may be required to confirm the extent of a restrictive hodzon. Also, the Regulations have some differentiation between a restrictive horizon (impedes water movement) and an impervious horizon (has a percolation rate greater than 120 minutes per inch. Another way to view this is that all impervious hodzons are restrictive, but not all restrictive horizons are impervious.

Perched water tables and slow permeabilitY caused by restrictive horizons can reduce treatment of septic effluent and cause transport of pathogens and nitrates into surface and subsurface horizons.

Many of the soils in the water table study have restrictive horizons that perched ground water for significant periods of time. The Leaksville, Zoar, McGary, Emporia, Spotsylvania-like, Ackwater, Acredale, Jackland, and Kelly soils all have pronounced restrictive horizons. These restrictive horizons have a spectrum of features and properties. Generally the soils were restrictive because of heavy clay textures, soil structure that limits permeability, dense and compact soil materials, firm in place parent materials or weathered bedrock, or very plastic, high shrink-swell clay horizons.

The Jackland and Kelly soils have very plastic, high shrink-swell clayey subsoil horizons that perched water a majority of time. It appears that once the plastic Bt horizons became wet, they basically stayed wet. The Jackland soil at times had a perched water table within 12 inches of the soil Surface. This shallow depth does not allow for a spray irrigation system, according the Virginia Sewage Regulations.

The Emporia soil is one of the most widespread soils in the Coastal Plain, and the Emporia soils in the water table study had a perched water table for extended periods. The restrictive horizons in Emporia soils can be deceptive at first glance because the soil materials in the Bt horizons do not appear to be overly dense and compact. However, most Emporia soils perch water extensively during the winter and spring. For instance, the Emporia soils had perched water tables for three to five months. The depth of the water table and its duration allow for use of some of the alternative onsite systems that use pretreatment of the effluent.

The Leaksville soil, in the Danville Triassic basin, had a perched water table for nearly four months dudng the water table study period. This soil had chroma 3 and 4 mottles that were accurate morphological features for predicting soil wetness.

Ackwater soils have lower Bt horizons that are mottled with shades of red, yellow and gray. These horizons are usually sandy clay loam to clay loam in texture and are dense in place. Consistence is usually firm in place. The firmness restricts the permeability of the horizon and promotes perching of water above.

The presence of yellowish red and pale brown mottles above this horizon is evidence of redoximorphic features.

Acredale soils have silty clay loam and silty clay Btg horizons that exhibit prismatic structure. Water movement in this soil is limited to vertical movement. The clays have moderate shrink-swell potential which further limits permeability. The presence of prismatic structure, moderate shrink-swell potential and gleyed conditions further reduces the soils ability to transmit water and air.

LITHOCHROMIC SOILS:

A general conclusion from the overall water table study is that lithochromic soils need careful evaluation for determining drainfield suitability because water table and soil wetness features may be masked or "lost" in the overall soil colors. Lithochromic soils have dominant soil colors that are inherited from the underlying parent rock.

The Triassic red bed soils are a good example where reddish brown soil colors are dominantly inherited from underlying reddish brown shale, siltstone, or fine-grained sandstone. Soil colors typically are reddish brown throughout the profile. In fact, when looking at a backhoe pit face from a short distance, it appears the uniformly colored soil is very thick and deep. A closer look usually reveals that the A and B horizons only extend 20 to 40 inches below the soil surface, and the rest is reddish brown weathered bedrock. The Penn soil in this water table study is a typical example of these thin solum soils.

On the other end of the lithochromic scale are the black and gray graphite schist soils weathered from metamorphic rocks of the Piedmont, and the black and gray shale soils weathered from sedimentary rocks (Brailler and Millboro formations) in the Ridge and Valley.

Lithochromic soils that are on subdued and Iow relief landforms make identifying subtle soil wetness features even more important, because these fiat landforms have little surface runoff. The Nason-like soil in this water table study had dominantly gray colors from top to bottom that were inherited mostly from the underlying gray graphite schist.. The Nason-like soil had significant soil wetness throughout the water table study period. (Note: the typical Nason soil is dominantly well drained and should not have soil wetness like the Nason-like soil.) Some of this wetness may have been accentuated by the Nason-like soil. being on the nearly level summit.

Aids in determining drainfield suitability in lithochromic soils would include avoiding marginal landscape positions and staying on at least slightly convex landforms; paying attention to any minor soil wetness or redoximorphic feature in the uniformly colored soils; carefully examining the soil and bedrock interface or soil boundary to determine if there are any clues that indicate that downward water movement is restricted (this would include increased accumulation of clayey textures, presence of red, yellowish red, and strong brown mottles, and manganese stains and coatings); visiting the site over three to four weeks, boring a few auger holes and recording the depth of free water in the profile. A better informed decision can then be made based on the aids above, especially using the quick and informal water table over three to four. weeks.

MANGANESE:

Manganese appeared in the forms of stains, concretions and masses at three of the selected sites. Manganese stains and very small concretions appear throughout the profile in many upland, colluvial and terrace soils in the central and western sections of Virginia.

Groseclose is identified as a well drained soil with manganese stains and concretions present from 9 to 60 inches. With slightly below normal rainfall, a lower sideslope position along the edge of a drainway, no water table was observed for any significant period. Mottles were not present in the profile to correlate with the manganese. In a well drained soil without mottles, manganese did not indicate a potential water table problem.

Zoar is identified as a moderately well drained soil with significant accumulations of manganese in the forms of nodules (concretions) and masses. A subscript "c" was attached to the master horizon designation between the depths of 23 to 76 inches. Mottles with 1 to 4 chroma were present and correlated to the manganese depths, even in the bright soil matrix. However, due to the drought and lack of a water table, no definitive statement may be made for the site.

The Cotaco site is identified as a somewhat poorly to moderately well drained soil. Manganese was present in the form of soft masses near the surface and hard nodules (concretions) in the lower profile depths. The soft masses correlate with the 1 to 4 chroma mottles and the 2.5Y matrix. The water table graphs and tables provide sufficient data to support the correlation. Soft manganese masses with a pale matrix and 1 to 4 chroma mottles, are a clue of a fluctuating water table. The surface of the water table rises close to the surface and remains for an extended period.

Few manganese stains and/or concretions are not satisfactory clues to denote soil wetness because they occur in nearly all soils. From the upper range of common (2% to 20%) or greater, manganese stains and concretions are better wetness indicators. Normally, 20% manganese or higher content is often present in a pale matrix and/or mottled horizon. Soft masses often appear higher in the profile and close to the upper surface of the water table. Soft masses also develop and help contribute to the browner color of the matrix and mottles.

SOIL DRAINAGE MANAGEMENT:

Soil drainage management is a part of the sewage regulations and is only allowed in the Cities of Chesapeake and Virginia Beach. It was a political and economic decision to allow ordedy development in the two cities with vast acreages of poody drained (hyddc) soils. In order to use these soils, you must (1) have at least 3 acres of uplands (excluding swamps, marshes, etc,), (2) surround the drainfield area with ditches that have an invert 6 inches deeper than the septic trenches, (3) maintain separation distances of 70 feet +/- 10 feet from the ditches and the wastewater system and (4) utilize soils with textures coarser than sandy clay, clay and silty clay.

The two soils studied were Acredale and Nimmo. Acredale soils typically have silt loam and silty clay loam Btg horizons with inclusions of silty clay, prismatic structure and moderately slow to slow permeability. Nimmo soils typically have loam and sandy clay loam Btg horizons, subangular blocky structure and moderately rapid permeabililty. Depth to sandy Cg horizons is usually greater than 60 inches in the Acredale and greater than 30 inches in the Nimmo. Family placement classification of Acredale soils is fine-silty while Nimmo is coarse-loamy.

Acredale soils had free water within the footprint of the subsurface drainfield for 488 days or 72% of the time within the Btgl horizon (less than 18 inches) and 572-656 days or 84-96% of~ the. time in the Btg2 horizon (18 to 42 inches). Free water, between the subsurface drainfield and the drainage ditches, was observed 251 days or 37% of the time within the Btgl horizon and 380-585 days or 56-86% of the time in the Btg2 horizon.

Nimmo soils had free water within the footprint of the subsurface drainfield for 8-50 days or 1-8% of the time within the Btgl horizon (less than 30 inches) and 112 days or 17% of the time in the Btg2 horizon (30-36 inches). Free water, between the subsurface drainfield and the drainage ditches, was observed 17-96 days or 3-15% of the time within the Btgl horizon and 214 days or 32% of the' time in the Btg2 horizon.

Due to the better permeability in Nimmo soils, the drainage plan to add treatment potential by lowering water tables has been successful. The drainage plan at this site has rendered this drainfield area comparable to that of a well drained soil. On the other hand, the drainage plan for Acredale has been quite unsuccessful in lowering the water table due to much slower permeability and adverse soil structure. The area within the footprint of the wastewater system had saturated conditions almost twice as long as the area outside the footprint. Comparatively, even the site outside the footprint of the wastewater system in Acredale had saturated'conditions more than three times that observed in the Nimmo soil.

POLLUTANTS

Several research sites had operating septic systems. The Emporia site with a Puraflo system had seasonal wetness within the gravel pad and the underlying standoff zone at least 1/2 to 2/3 of the time in winter-spring, or continuously for 3-4 months. The Emporia site with a conventional septic system had the seasonal water table in the standoff zone beneath the gravel trenches at least 1/2 to 3/4 of the time in the winter-spring, or continuously for 3-4 months.

The Acredale site, under Soil Drainage Management, had a conventional septic system. The water table was in the trenches or standoff zone beneath the gravel trenches at least 3/4 of the time in the winter-spring period, or continuously for up to 5 months.

While these septic systems were not operating in the designed or an approved manner, there was no surfacing of effluent and its associated health risks. However, there was potential contamination of the seasonal water table with untreated or partially treated wastewater and its health and environmental concerns (nitrates, pathogens). An additional concern at the Emporia sites is that if these systems seemed to avoid failure due to lateral water movement, that same movement was transporting pollutants away from the. site. The size of the pollutant plume and how far it extended from the site were not assessed during this study.

These sites with their unique soil characteristics, landscape positions, or manmade drainage should have had shallow, pretreatment alternative septic systems installed on these lots. It is clear that quite a number of soil series and specific landscape positions, which currently meet Health Department requirements, are wetter and/or more restrictive than would allow for the proper treatment and disposal of domestic wastewater. Minimum soil requirements for issuing septic permits will be need to be reevaluated to ensure the proper design and function of wastewater systems.

SOIL MORPHOLOGY TRAINING

The results and conclusions in the water table study will provide the basis for soil morphology training on soil wetness features and water tables to environmental health specialists working in the Virginia Department of Health onsite wastewater program. The individual study sites are located throughout Virginia and will provide ample opportunity for training, especially for newly hired environmental health specialists who are required to complete the week-long VDH Basic Soils course. (The Virginia Tech soil scientists who authored this water table report teach the Basic Soils course at least two times a year.)

The many environmental health specialists, supervisors, and managers who were instrumental in locating study sites and securing permission to use them will

SOIL EVALUATED: Ackwater fine sandy loam

LOCATION:

This research site was located in the northern portion of Middlesex County, Virginia. Refer to the accompanying portion .of the Wilton U.S. Geologic Survey topographic map for the general character of the area. The accompanying detailed site sketch shows the location of two automated WL-40 data loggers on this residential property.

RATIONALE FOR SITE SELECTION:

There were several reasons for using this site. First, the type of soil at the site, Ackwater, represents a major soil type located over large areas in the state. To study it would provide valuable information that could apply to numerous sites considered for onsite septic systems. Second, while the Ackwater soil does not meet Virginia criteria to allow installation of a conventional gravity drainfield, it does allow for permitting of certain alternative type systems. And finally, the residence at this site employs an alternative onsite wastewater disposal system, so a water table study would provide information on how well this alternative septic system works in problem soils.

SOIL AND SITE INFORMATION:

The soil at this site formed in moderately fine textured, stratified, unconsolidated, fluvio-marine sediments of the middle Coastal Plain. There was a long, gently sloping hillside that lies upslope of the site. The site was on the lower sideslope, very near a major drainageway and small pond. The wells were located in a small wooded area of mixed hardwoods and Ioblolly pine adjacent to. the dwelling. Well # I was located in the footprint of the Puraflo (peat moss) Biofilter system and Well # 2 was located 60 feet upslope of the system.

The published Soil Survey of Middlesex County, Vir.clinia, Michael E. Newhouse, et. al., December 1985, shows the research site as being mapped as Ackwater silt loam (1). Ackwater is a moderately well drained soil. The research site has surface textures of fine sandy loam vs. the silt loam and coarser textures throughout than is listed in the mapping unit. This would have been considered an inclusion in the mapping unit.

A detailed soil profile description was made at the site' and is included. When compared to the official soil series description for the Ackwater series (refer to the Appendix), the soil at this site falls outside the range of characteristics. That means the soil was not typical or representative of Ackwater soils. This soil had less clay and silt in the Bt and Btg horizons than is allowed in Ackwater. This soil site is more' closely related to Slagle soils and is listed as an inclusion in the Ackwater mapping unit.

Since the soil was unsuitable for a conventional gravity drainfield, a Puraflo (peat moss) Biofilter system was permitted due to its reduced area requirements, reduced standoff requirements to wetness indicators and experimental status. This soil would have required a 12 to 16 inch standoff below trench bottom to wetness indicators due 'to texture and permeability. The depth to wetness indicators should have been 30 to 34 inches and this site had only 28 inches to chroma 2 or less mottles. The 6 inches of %-1 inch diameter clean gravel was installed at grade, the modules set on the gravel Pad, pipes connected and then soil backfill material used to level and landscape the site.

CLIMATIC DATA FOR THE SITE:

Precipitation'was monitored at the site by the homeowner. This current data was compared to the precipitation data published in the Soil Survey of Middlesex Countv, Vir.qinia referenced above. This precipitation data from the home site was used to evaluate rainfall during the study period. The precipitation comparison graph shows how each month's rainfall total compares to the monthly 29-year average (1961-1990).

It is apparent that 1999 was a very abnormal year. Hurricanes Dennis, Floyd and Irene produced rainfall totals in excess of 18 inches during a six week period from September 3 through October 18. For the March-June period, precipitation was slightly below normal with 1.34 inches short or 91%. For the July-December period, precipitation was dramatically above normal. In fact, rainfall was 159% of the long-term average for that period. Therefore, the water table levels at the site would be expected to be shallower (nearer to the surface) than during a year with normal precipitation.

For the period January-June 2000, total precipitation was 1.58 inches above the 30-year average or 107%. That means that the water table levels wOuld be expected to be normal at the site.

For the period July-December 2000, monthly rainfall was moderately above normal. Precipitation was 8.95 inches above the 30-year average or 137%. That means that the water table levels would be expected to be above normal at the site.

For the period January-June 2001, total precipitation was 0.61 inches above the 30-year average or 103%. That means that the water table levels would be expected to be normal at the site.

Sixteen of the twenty eight months (March, April, August, September and

October 1999, January, March, Apdl, May, July, August, September and December 2000 and March, May and June 2001) had precipitation levels above normal. For the entire study period of March 1999 through June 2001, overall precipitation was 24.25 inches above the 30-year average or 122%. Water table levels would be expected to be above normal at the site.

RESULTS:

Two automated data loggers were installed at the site on February 24,1999. Wells were installed in the same soil, same landscape position and at the same topographic elevation. Well # 1 was installed within the footprint of an operating Puraflo wastewater system and Well # 2 was installed 58 feet away. Well # 2 was representative of the soil conditions at the Puraflo (peat moss) Biofllter system site but was remote enough to be unaffected by the wastewater system. Due to operator error, Wells # 1 and # 2 were not programmed properly and the collection of water table data did not commence until March 16,1999. There was continuous data collection from the starting date until June 30, 2001 for both Well # 1 and Well # 2.

The Ackwater soil at this site had pale brown (10YR 6~3) and yellowish red (5YR 5/6) mottles in a yellowish brown matrix from 24 to 28 inches in the Bt2 horizon and yellowish red (5YR 5/6) and gray (10YR 6/1) mottles (or iron depletions) in a yellowish brown matrix from 28 to 42 inches in the Bt3 horizon. This Bt3 horizon also had restrictive permeability. These characteristics make it .a moderately well drained soil. These soils normally have a perched water table. The mottling at shallower depths in the Bt2 was suspected to be associated with the fluctuating water table, perched above the Bt3 horizon.

The water table hydrograph of March - June, 1999 shows the presence of free water in the soil within 12 inches for 0-1 day, 12-18 inches for 1-2 days, 18-24 inches for 1-3 days, 24-30 inches for 2-4 days, 30-36 inches for 5-7 days, 36-40 inches for 9-41 days and dry for 66-98 days. Rainfall for this period was above average or 14.35 inches. March and April were above normal in precipitation but May and June were below normal.

The March - June, 1999 Groundwater Data Table shows that the surface of the free water for Well # 1 was below the A and E horizons for the time during this 107 day period, in the Bt1 horizon 1 day or 1% of the time, in the Bt2 horizon 2 days or 2% of the time and the Bt3 horizon 5-9 days or 5-9% of the time. The Bt4 horizon was dry for 98 days or 92% of the time. For Well # 2, the surface of the free water was in the A and E horizons 1 day or 1% of the time during this i07 day period, in the Bt1 horizon 2-3 days or 2-3% of the time, in the Bt2 horizon 4 days or 4% of the time and the Bt3 horizon 7-41 days or 6-38% of the time. The Bt4 horizon was dry for 66 days or 62% of the time.

The water table hydrograph of July - December, 1999 shows the presence of free water in the soil within 12 inches for 2-3 days, 12-!8 inches for 4-5 days, 18-24 inches for 6 days, 24-30 inches for 10-15 days, 30-36 inches for 15-28 days, 36-40 inches for 52-63 days and' dry for 121-132 days. Rainfall for this period was much above average or 38.85 inches. August, September and October were above normal in precipitation but July, November and December were below normal.

The July - December, 1999 Groundwater Data Table shows that the surface of the free water for Well # 1 waS in the A and E horizons 2 days or 1% of the time during this 184 day pedod, in the Bt1 horizon 5-6 days or 3% of the time, in the Bt2 horizon 15 days or 8% of the time and the Bt3 horizon 28-52 days or 8-15% of the time. The Bt4 horizon was dry for 132 days or 72% of the time. For Well # 2, the surface of the free water was in the A and E horizons 3 days or 2% of the time during this 184 day period, in the Bt1 horizon 4-6 days or 2-3% of the time, in the Bt2 horizon 10 days or 6% of the time and the Bt3 horizon 15-63 days or 8-35% of the time. The Bt4 horizon was dry for 121 days or 65% of the time.

The water table hydrograph of January - June, 2000 shows the presence of free water in the soil within 12 inches for 1-2 days, 12-18 inches for 3-4 days, 18-24 inches for 8 days, 24-30 inches for 16-31 days, 30-36 inches for 29-65 days, 36-40 inches for 129-155 days and dry for 27-53 days. Rainfall for this period was slightly above average or 24.47 inches. January, March, April and May were above normal in precipitation but February and June were below normal.

The January - June, 2000 Groundwater Data Table shows that the surface of the free water for Well # 1 was in the A and E horizons 1 day or 1% of the time during this 182 day period, in the Bt1 horizon 4-8 days or 2-4% of the time, in the Bt2 horizon 31 days or 16% of the time and the Bt3 horizon 65-155 days or 35-85% of the time. The Bt4 horizon was dry for 27 days or 15% of the time. For Well # 2, the surface of the free water was in the A and E horizons 2 days or 1% of the time during this 182 day period, in the Bt1 horizon 3-8 days or 2-5% of the time, in the Bt2 horizon 16 days or 9% of the time and the Bt3 horizon 29-129 days or 16-71% of the time. The Bt4 horizon was dry for 53 days or 28% of the time.

The water table hydrograph of July - December, 2000 shows the presence of free . water in the soil within 12 inches for 0-2 days, 12-18 inches for 4-7 days, 18-24 inches for 10-13 days, 24-30 inches for 17-46 days, 30-36 inches for 30-123 days, 36-40 inches for 144-146 days and dry for 38-40 days. Rainfall for this period was well above average or 33.35 inches. July, August, September and December were above normal in precipitation but October and November were below normal. October had no precipitation.

The July - December, 2000 Groundwater Data Table shows that the surface of the free water for Well # 1 was below the A and E horizons for the time during this 184 day period, in the Bt1 horizon 7-13 days or 4-7% of the time, in the Bt2 horizon 46 days or 25% of the time and the Bt3 horizon 123-146 days or 67-80% of the time. The Bt4 horizon was dry for 38 days or 21% of.the time. For Well # 2, the surface of the free water was in the A and E horizons 2 days or 1% of the time during this 184 day period, in the Bt1 horizon 4-10 days or 2-6% of the time, in the Bt2 horizon 17 days or 9% of the time and the Bt3 hodzon 30-144 days or 17-79% of the time. The Bt4 hodzon was dry for 40 days or 21% of the time.

The water table hydrograph of January - June, 2001 shows the presence of free water in the soil within 12 inches for 0-1 daysl 12-18 inches for 2-8 days, 18-24 inches for 3-32 days, 24-30 inches for 7-84 days, 30-36 inches for 18-138 days, 36-40 inches for 90-156 days and dry for 25-91 days. Rainfall for this pedod was above average or 23.5 inches. March, May and June were above normal in precipitation but January, February and April were below normal.

The January - June, 2001 Groundwater Data Table shows that the surface of the free water for Well # 1 was below the A and E horizons for the time during this 181 day period, in the Bt1 horizon 8-32 days or 4-17% of the time, in the Bt2 horizon 84 days or 46% of the time and the Bt3 horizon 138-156 days or 76-86% of the time. The Bt4 horizon was dry for 25 days or 15% of the time. For Well # 2, the surface of the free water was in the A and E hodzons 1 day or 1% of the time during this 181 day period, in the Bt1 hodzon 2-3 days or 1-2% of the time, in the Bt2 horizon 7 days or 4% of the time and the Bt3 horizon 18-90 days or 10-50% of the time. The Bt4 horizon was dry_for 91 days or 50% of the time.

CONCLUSIONS:

This site had precipitation levels above normal for 16 months of the 28 months the study was conducted. Those sixteen months, March, April, August, September and October, 1999; January, March, April, May, July, August, September and December, 2000; and March, May and June, 2001; had totals of 107.52 inches, 42.33 inches above normal. That relates to 165% of normal precipitation for the sixteen months. The total study pedod (28 months) had 134.52 inches. Based on the 25-year average, this relates to 122% of normal precipitation.

As a result of this above normal precipitation, free water was present for significant periods of time during the study period. In addition, the depth to free water was much shallower than where gray mottles were found in the soil. Once the water table rose in the soil, it remained for an extended period of time.

Free water was observed in the Ap and E horizons for short periods of time and was always associated with precipitous rises in the water table. For the entire study period, free water was in these horizons for 3 to 9 days of the total 838 days or less than 1 percent of the time, though not continuously. There were no soil morphological features that could be related to the presence of water in the soil for the number of days observed.

Free water was observed in the Bt1 horizon for 30 to 60 days of the total 838 days dudng the entire study pedod and was always associated with sharp rises in the water table. This relates to 4 to 7 percent of the time. There were no s°il morphological features that could be related to the presence of water in the soil for the number of days observed.

Free water was observed in the Bt2 hodzon for 54 to 178 days of the total 838 days during the entire study period and was always associated with sharp dses in the water table. This relates to 6 to 21 percent of the time. Yellowish red (5YR 5/6) and pale brown (10YR 6/3) mottles were soil morphological features that could be related to the presence of water in the soil for the number of days observed.

Free water was observed in the Bt3 horizon for 467 to 518 days of the total 838 days during the entire study period and was always associated with sharp rises in the water table. This relates to 56 to 62 percent of the time. Yellowish red (5YR 5/6) and gray (10YR 6/1) mottles were soil morphological features that could be related to the presence of water in the soil for the number of days observed.

Free water was observed in the Bt4 hOrizon for 320 to 371 days of the total 838 days during the entire study period and was always associated with sharp rises in the water table. This relates to 38 to 44 percent of the time. Yellowish brown (10YR 5/8), gray (10YR 6/1) and yellowish red (5YR 5/6) mottles in a mottled matrix were soil morphological features that could be related to the presence of water in the soil for extended periods of time.

The upper Bt horizon had no evidence of redoximorphic features (mottles) that COuld be related to the presence of water in the soil for extended periods of time. During the winter-spring time of the year, the seasonal water table was present in the Bt1 horizon for less than 1/10 of the time.

The presence of yellowish red (5YR 5/6) and pale brown (10YR 6/3) redoximorphic features (mottles) were soil morphologic features that could be related to the presence of water in the soil for extended periods of time. During the winter-spring time of the year, the seasonal water table was present in the Bt2 horizon for 1/15 to 1/4 of the time.

The presence of yellowish red (5YR 5/6) and gray (10YR 6/1) redoximorPhic features (mottles) were soil morphologic features that could be related to the presence of water in the soil for extended periods of time. During the winter-spring time of the year, the seasonal water table was present in the Bt3 horizon for 1/2 to 2/3 of the time.

It must be remembered that when the surface of the water table was in one of the upper horizons such as the Bt1,' Bt2 and Bt3 horizons, the Bt4 horizon was saturated. Free water was observed in the Bt4 horizon for more than 2/3 of the time. This horizon had yellowish red (5YR 5/6) and gray (10YR 6/1) redoximorphic features (mottles) in a mottled horizon.

As was noted earlier, this soil exceeded the minimum state requirements for a conventional gravity drainfield based on soil morphology. Based on the period studied, it is apparent that if a conventional septic system had been installed, the gravel filled trenches (at a depth of 18 inches) would have been inundated with free water for extended periods of time. Based on the state sewage regulations in effect when the permit was issued, a 16 inch zone of suitable soil beneath the gravel filled trenches would have been required (the "stand-off zone") for treatment and disposal of the wastewater. Based on this research, the seasonal water table would have been in the "stand-off zone" at least 12% to 44% of the time during a winter-spring period. Soil morphology indicated this soil was unsuitable for a conventional gravity drainfield and the monitoring data taken while there was above normal precipitation showed the soil was unsuitable.

A Puraflo (peat moss) Biofilter system was installed at this site and it required a "stand-off zone" of 24 inches beneath the surface. Based on this installation depth, the seasonal water table would have periodically risen into the "stand-off zone". Based on this research, the seasonal water table would have been in the "stand-off zone" at least 3% to 9% of the time during a winter-spring period. It should also be pointed out that the area beneath the Puraflo (peat moss) Biofilter system has become wetter with time. As the study has progressed, the water table mound has gained in height beneath the wastewater system. This type of system uses a reduced footprint for wastewater disposal due to the high quality of the wastewater. This could be an early sign of soil clogging beneath the wastewater system. Further studies should be made.

Ackwater fine sandy loam

Profile for Well # 1: (WL40)
,~,--0 to 9 inches, mottled white (10YR 8/1) and dark grayish brown (10YR 4/2) loamy sand; single grained; loose, nonsticky, nonplastic.

E--9 to 12 inches, light yellowish brown (10YR 6/4) fine sandy loam; massive; friable, slightly sticky, nonplastic.

Btl--12 to 24 inches, yellowish brown (10YR 5~8) sandy clay loam; weak medium subangular blocky structure; friable, slightly sticky, slightly plastic.

Bt2--24 to 28 inches, yellowish brown (10YR 5/8) sandy clay loam; many medium distinct yellowish red (5YR 5/6) and pale brown (10YR 6/3) mottles; weak medium subangular blocky structure; fdable, slightly sticky, slightly plastic.

Bt3--28 to 42 inches, yellowish brown (10YR 5/8) clay loam; many medium distinct yellowish red (5YR 5/6) and gray (10YR 6/1) mottles; moderate medium subangular blockY structure; firm, sticky, slightly plastic.

Bt4--42 to 48 inches, mottled yellowish brown (10YR 5/8), gray (10YR 6/1) and yellowish red (5YR 5/6) sandy clay loam; weak medium subangular blocky structure; friable, slightly sticky, slightly plastic.

Remarks: This profile taken from an auger hole.

Profile for Well # 2: (WL40)

A--0 to 3 inches, dark grayish brown (10YR 4/2) fine sandy loam; weak coarse granular structure; friable, slightly sticky, nonplastic.

E--3 to 12 inches, light yellowish brown (10YR 6/4) fine sandy loam; massive; friable, slightly sticky, nonplastic.

Bt1--12 to 24 inches, yellowish brown (10YR 5/8) sandy clay loam; weak medium subangular blocky structure; fdable, slightly sticky, slightly plastic.

Bt2--24 to 28 inches, yellowish brown (10YR 5/8) sandy clay loam; many medium distinct yellowish red (SYR 5/6) and pale brown (10YR 6/3) mottles; weak medium subangular blocky structure; friable, slightly sticky, slightly plastic.

Bt3--28 to 42 inches, yellowish brown (10YR 5/8) clay loam; many medium distinct yellowish red (5YR 5/6) and gray (10YR 6/1) mottles; moderate medium subangular blocky structure; firm, sticky, slightly plastic.

Bt4--42 to 48 inches, mottled yellowish brown (10YR 5/8), gray (10YR 6/1) and yellowish red (5YR 5/6) sandy clay loam; weak medium subangular blocky structure; friable, slightly sticky, slightly plastic.

Remarks: This profile taken from an auger hole.

Table I - - Ackwater fine sandy loam Groundwater Data Table
March-June, 1999 (107 Days)

	Well # 1				Well #2			
			Percent				Percent	
Depth Range (in.)	Number of Days	Percent Time	Cumulative Days	Cumulative! Days	Number of Days	Percent Time	~Cumulative Days	iCumulative Days _
0-6	0	0	0	0	0	0	0	0 _
6.1,12	0	0	0	0	1	1	1	1
12.1-18	1	1	1	1	1	1	2	2
18.1-24	0	0	1	1	1	1	3	3
24.1-30	1	1	2	2	1	1	4	4
30.1-36	3	2	5	5	3	3	7	6
36.1-40	4	4	9	9	34	31	41	38
- Dry	98	92	107	100	66	62	107	100

Table 2 - - Ackwater fine sandy loam Groundwater Data Table
July-December, 1999 (184 Days)

	Well # 1				Well # 2			
			Percent				Percent	
Depth Range (in.)	Number of Days	Percent Time	Cumulative Days	Cumulative Days	Number of Days	Percent Time	Cumulative Days	Cumulative Days
0-6	0	0	0	0	0	0	0	0
6.1-12	2	1	2	1	3	2	3	2
12.1-18	3	2	5	3	1	1	4	2
18.1-24	1	0	6	3	2	1	6	3
24.1-30	9	5	15	8	4	2	10	6
30.1-36	13	-7	28	15	5	3	15	8
36.1-40	24	13	52	28	48	26	63	35
Dry	132	72	184	100	121	65	184	100

Number of Days column refers to the number of days the surface of the free water was present within the depth range.

Percentage of Time column refers to the percent of time the water was present within the depth range.

Cumulative Days column refers to the total number of days the water was present within the depth range.

Percentage of Cumulative Days refers to the percent of total time the water was present within the depth range.

DRY corresponds to the number of readings (converted to days) where the monitoring well recorded no water in the hole.

Days in the column headings corresponds to the number of data logger readings within a depth range divided by the number (normally 2, 4 or 8) of data logger readings per day.

Table 3_- - Ackwater fine sandy loam Groundwater Data Table
JanUary-June, 2000 (182 Days)

	Well # 1				Well # 2			
				Percent				Percent
Depth Range (in.)	Number of Days	Percent Time	Cumulative Days	Cumulative Days	Number of Days	Percent Time	Cumulative Days	Cumulative Days
0-6	0	0	0	0	1	1	1	1
6.1-12	1	1	1	1	1	1	2	1
12.1-18	3	1	4	2	1	1	3	2
18.1-24	4	2	8	4	5	3	8	5
24.1-30	23	12	31	16	8	4	16	9
30.1-36	34	19	65	35	13	7	.29	16
36.1-40	90	50	155	85	100	55	129	71
Dry	27	15	182	100	53	28	182	100

Table 4 - - Ackwater fine sandy loam Groundwater Data Table
July-December, 2000 (184 Days)

	Well # 1				Well # 2			
				Percent"				Percent
Depth Range (in.)	Number of Days	Percent Time	Cumulative Days	Cumulative Days	Number of Days	Percent Time	Cumulative Days	Cumulative Days
0-6	0	0	0	0	0	0	0	0
6.1-12	0	0	0	0	2	1	2	1
12.1-18	7	4	7	4	2	I	4	2
18.1-24	6	3	13	7	6	4	10	6
24.1-30	33	18	46	25	7	4	17	9
30.1-36	77	42	123	67	13	7	30	17
36.1-40	23	12	146	80	114	62	144	79
Dry	38	21	184	100	40	21	184	100

Number of Days column refers to the number of days the surface of the free water was present within the depth range.

Percentage of Time column refers to the percent of time the water was present within the depth range.

Cumulative Days column refers to the total number of days the water was present within the depth range.

Percentage of Cumulative Days refers to the percent of total time the water was present within the depth range.

DRY corresponds to the number of readings (converted to days) where the monitoring well recorded no water in the hole.

Days in the column headings corresponds to the number of data logger readings within a depth range divided.by the number (normally 2, 4 or 8) of data logger readings per day.

Table 5 - - Ackwater fine sandy loam Groundwater Data Table
January-June, 2001 (181 Days)

	Well # 1				Well # 2			
	I		Percent				Percent	
Depth Range (in.)	Number of Days	Percent Time	Cumulative Days	Cumulative Days	Number of Days	Percent Time	Cumulative Days	Cumulative Days
0-6	0	0	0	0	0	0	0	0
6.1-12	0	0	0	0	1	1	1	1
12.1-18	8	4	8	4	1	I	2	
18.1-24	24	13	32	17	1	I	3	2
24.1-30	52	29	84	46	4	2	7	4
30.1-36	54	29	138	76	11	5	18	10
36.1-40	18	10	156	86	72	40	90	50
Dry	25	15	181	100	91	50	181	100

Number of Days column refers to the number of days the surface of the free water was present within the depth range.

Percentage of Time column refers to the percent of time the water was present within the depth range.

Cumulative Days column refers to the total number of days the water was present within the depth range.

Percentage of Cumulative Days refers to the percent of total time the water was present within the depth range.

DRY corresponds to the number of readings (converted to days) where the monitoring well recorded no water in the hole.

Days in the column headings corresponds to the number of data logger readings within a depth range divided by the number (normally 2, 4 or 8) of data logger readings per day.

Middlesex County
Ackwater Fine Sandy Loam
Scale' 1"= 40'

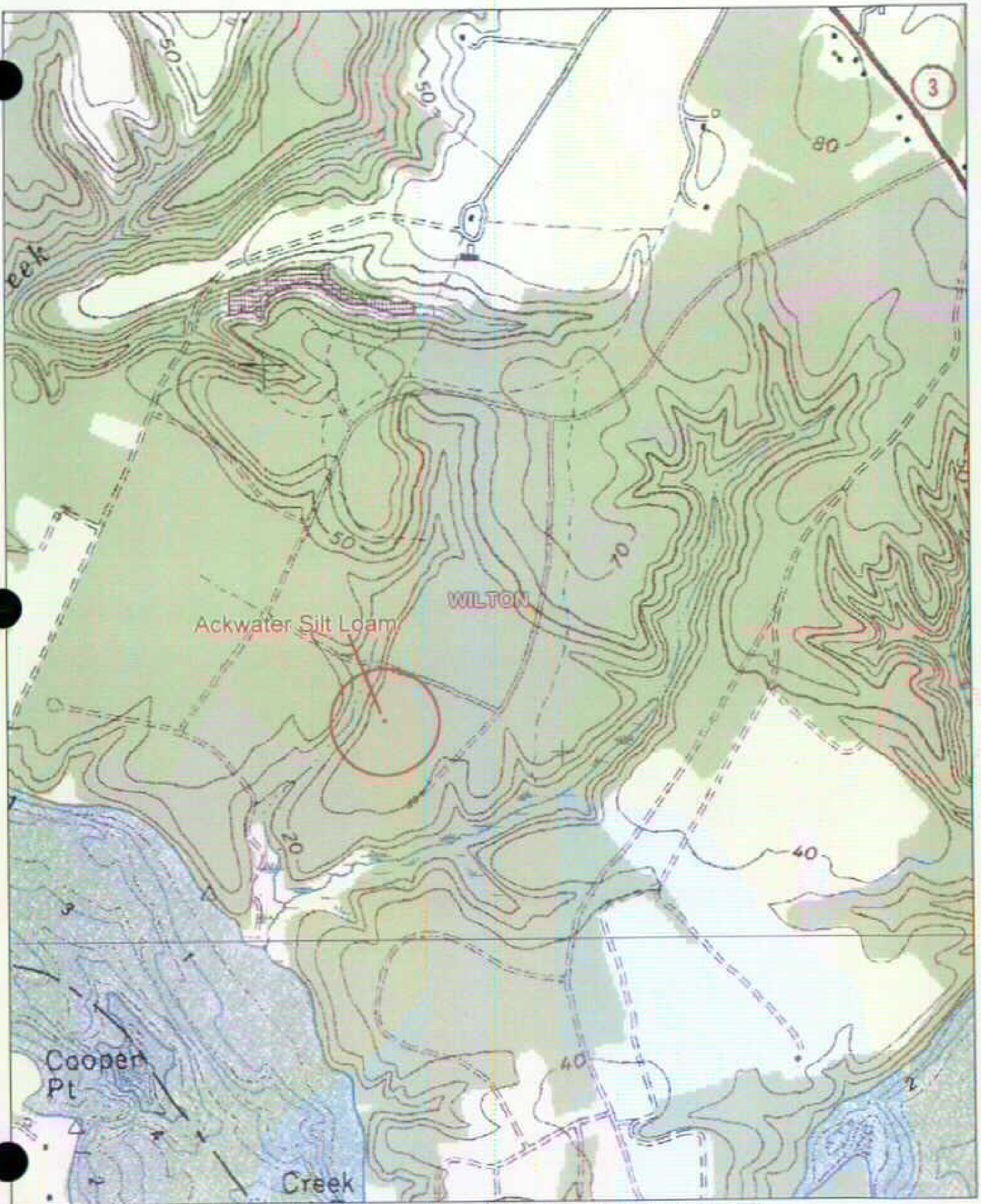
Pond

130'

15'x31'
Puraflo Pad House
20'-"" ~55' ~-

58~ Data Logger#1 WL-40

©
Data Logger #2
WL.-40



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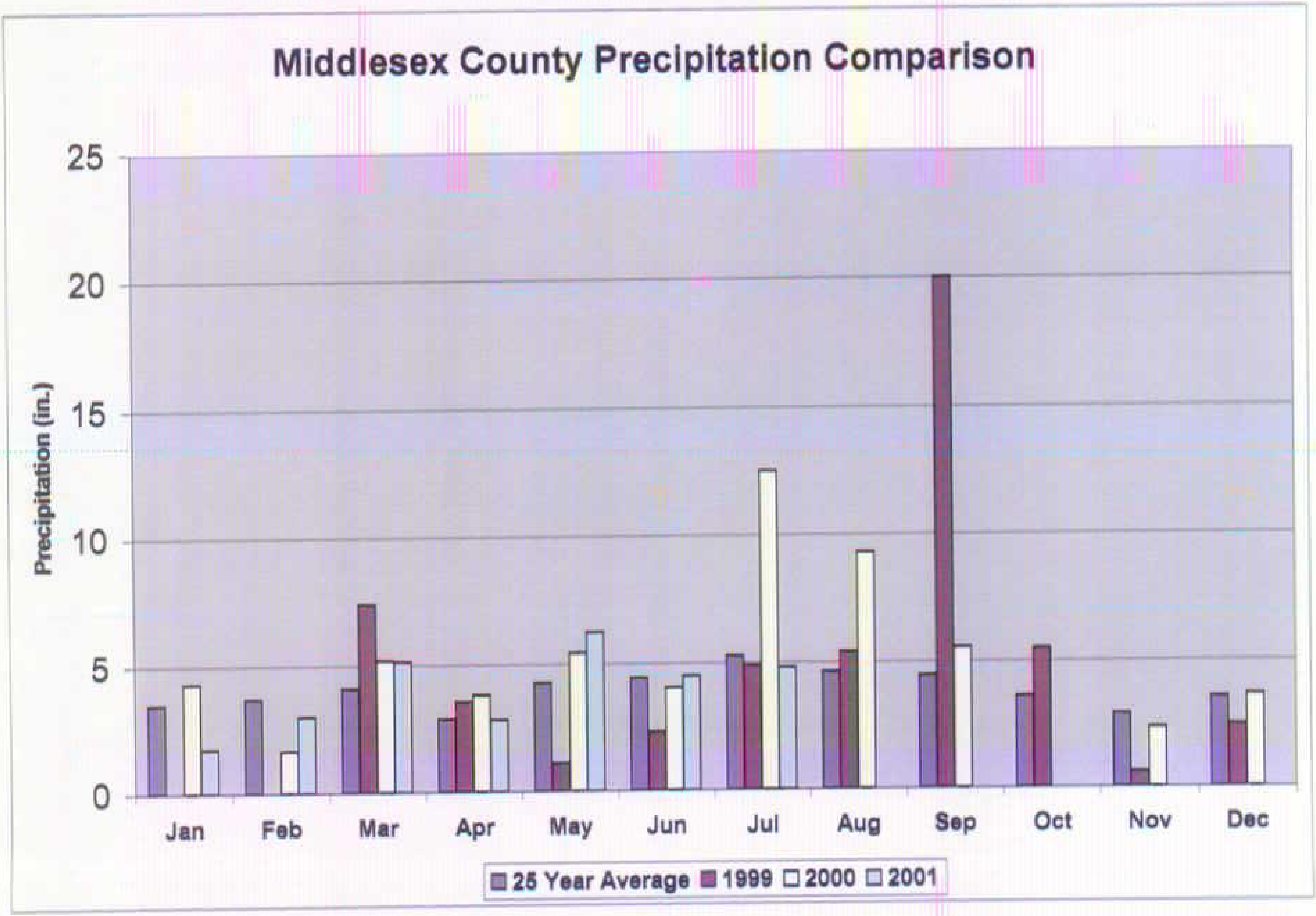
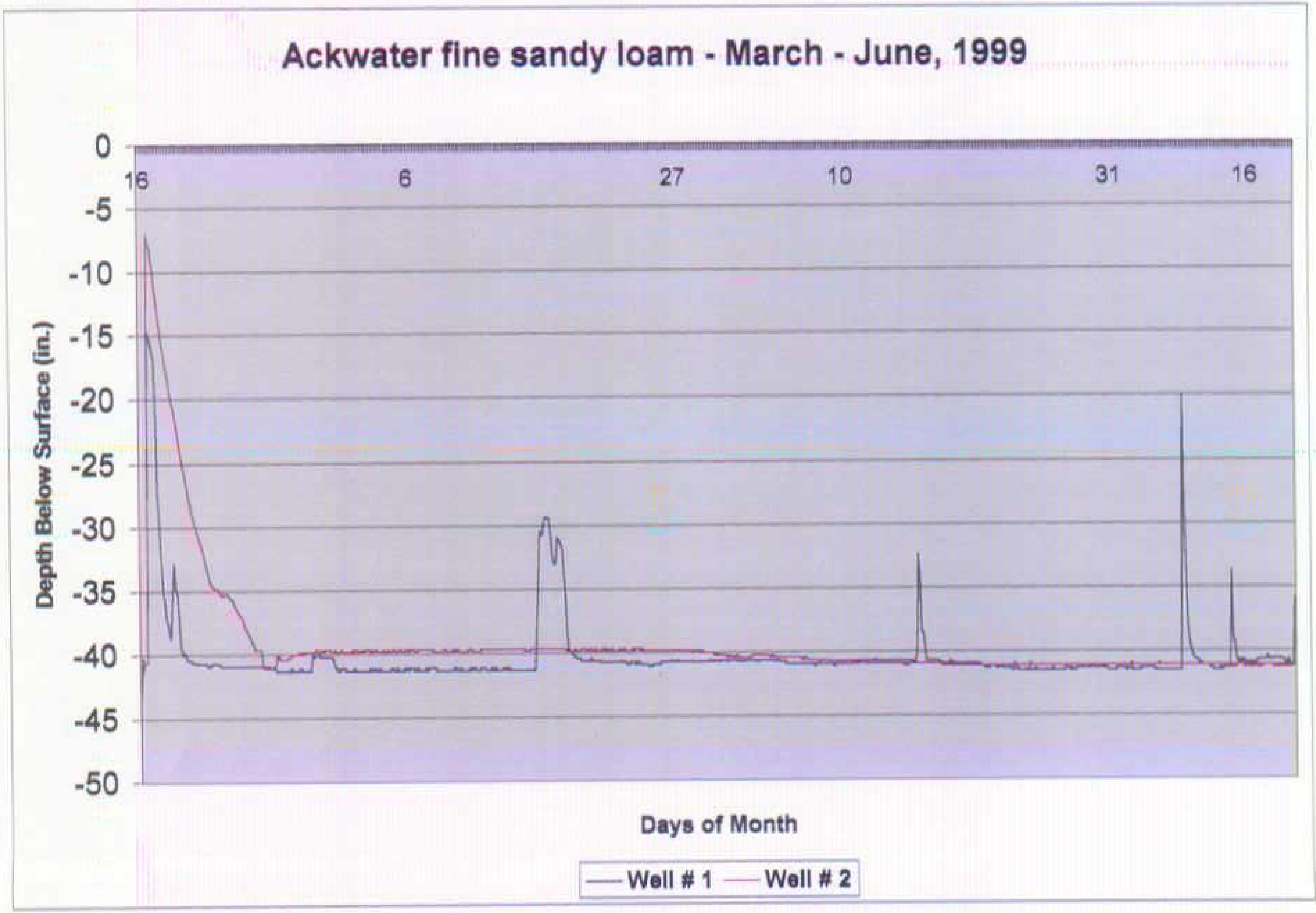
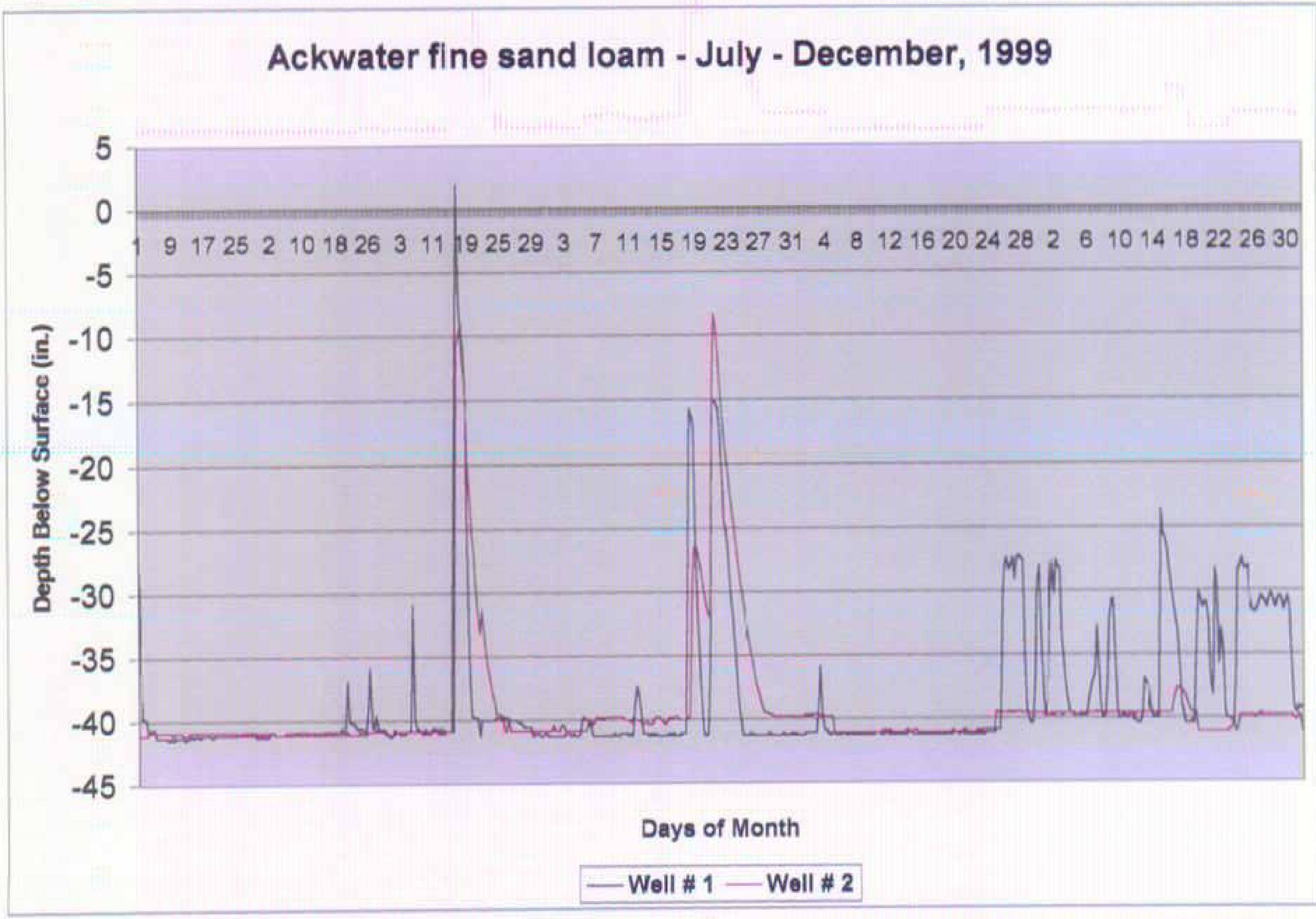
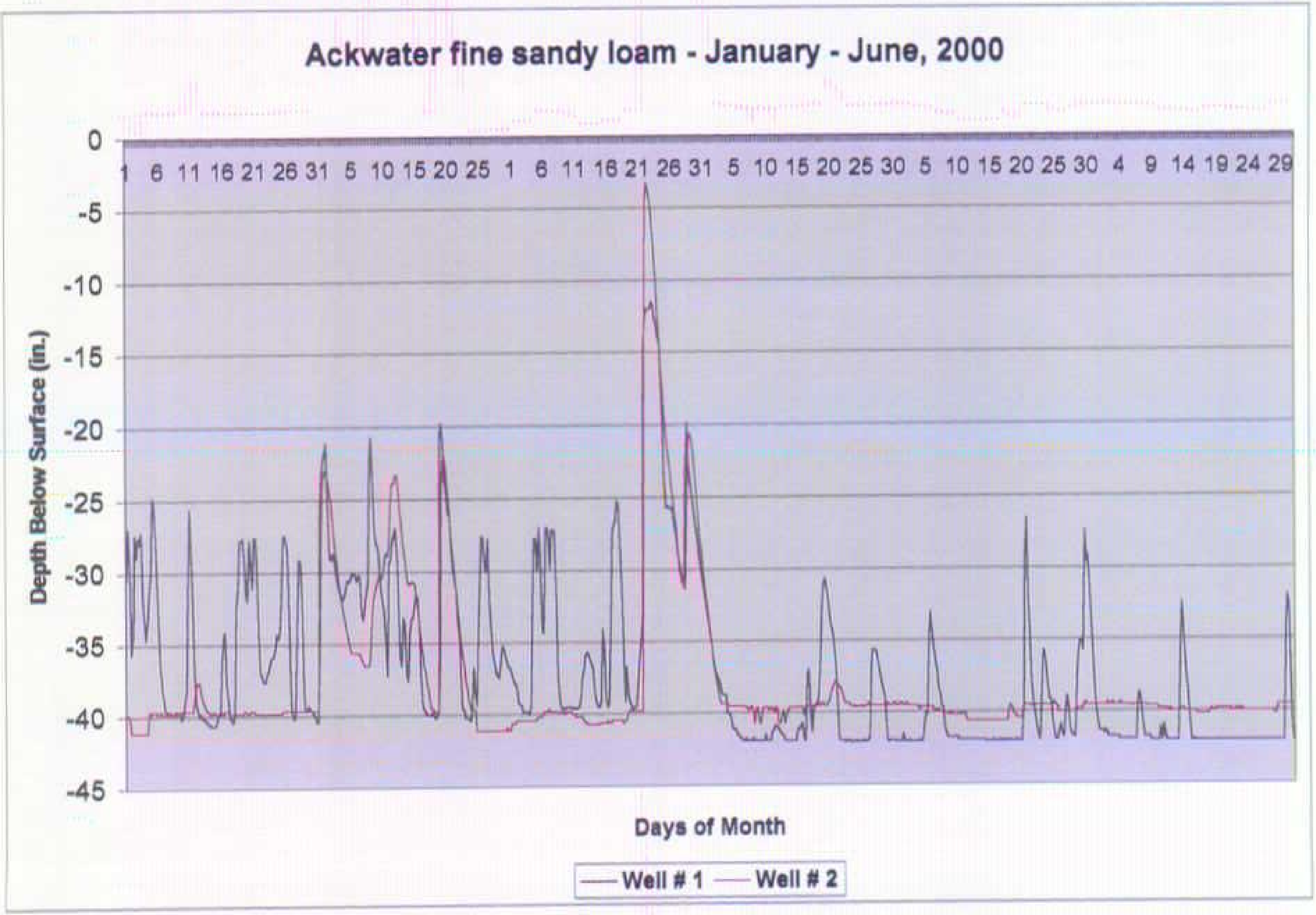

Middlesex County Precipitation Comparison
25
20
15
10
5
0
Precipitation (in.)
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
25 Year Average
1999
2000
2001

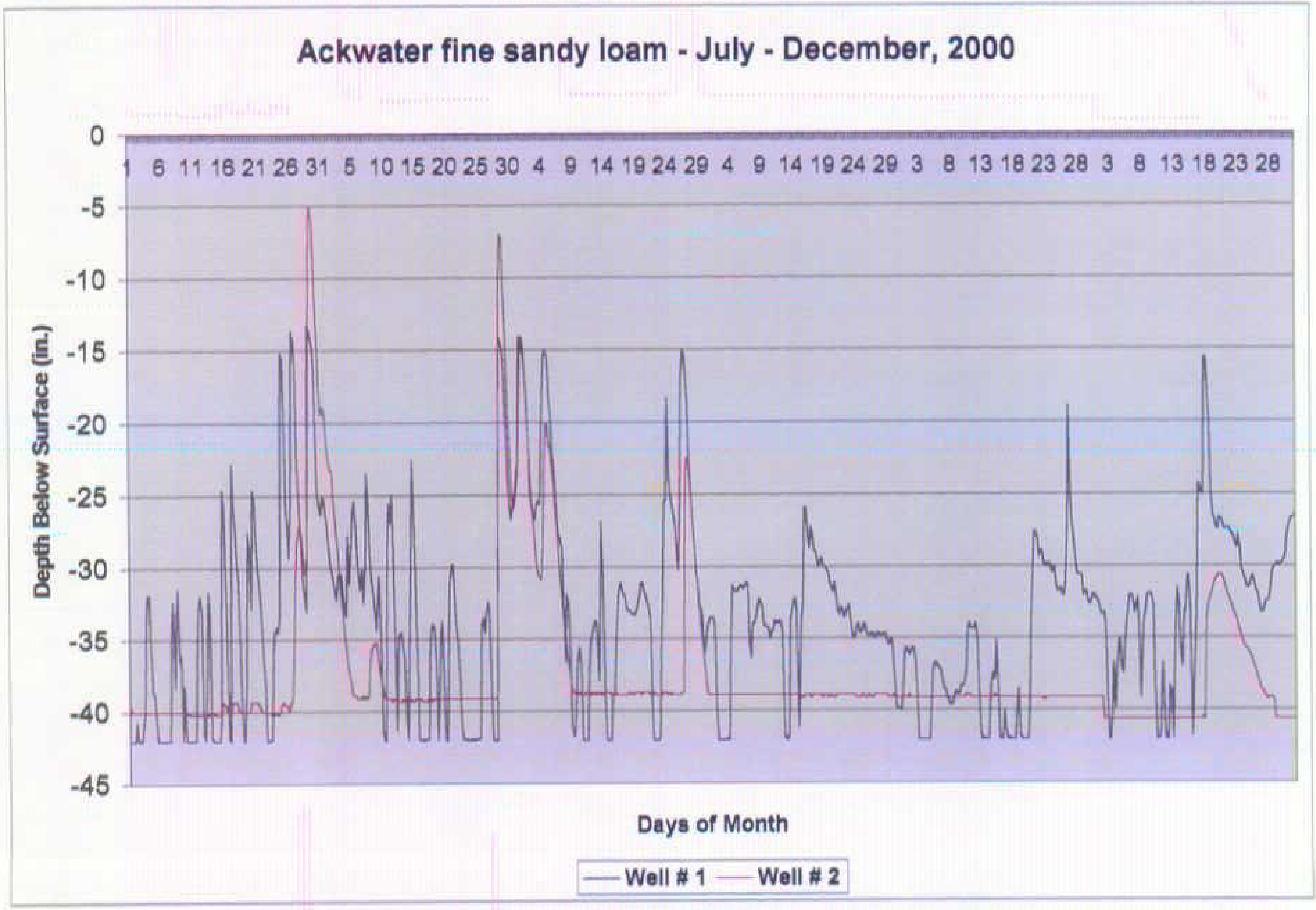

Ackwater fine sandy loam - March - June, 1999
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
Depth Below Surface (in.)
16
6
27
10
31
16
Days of Month
Well # 1
Well # 2

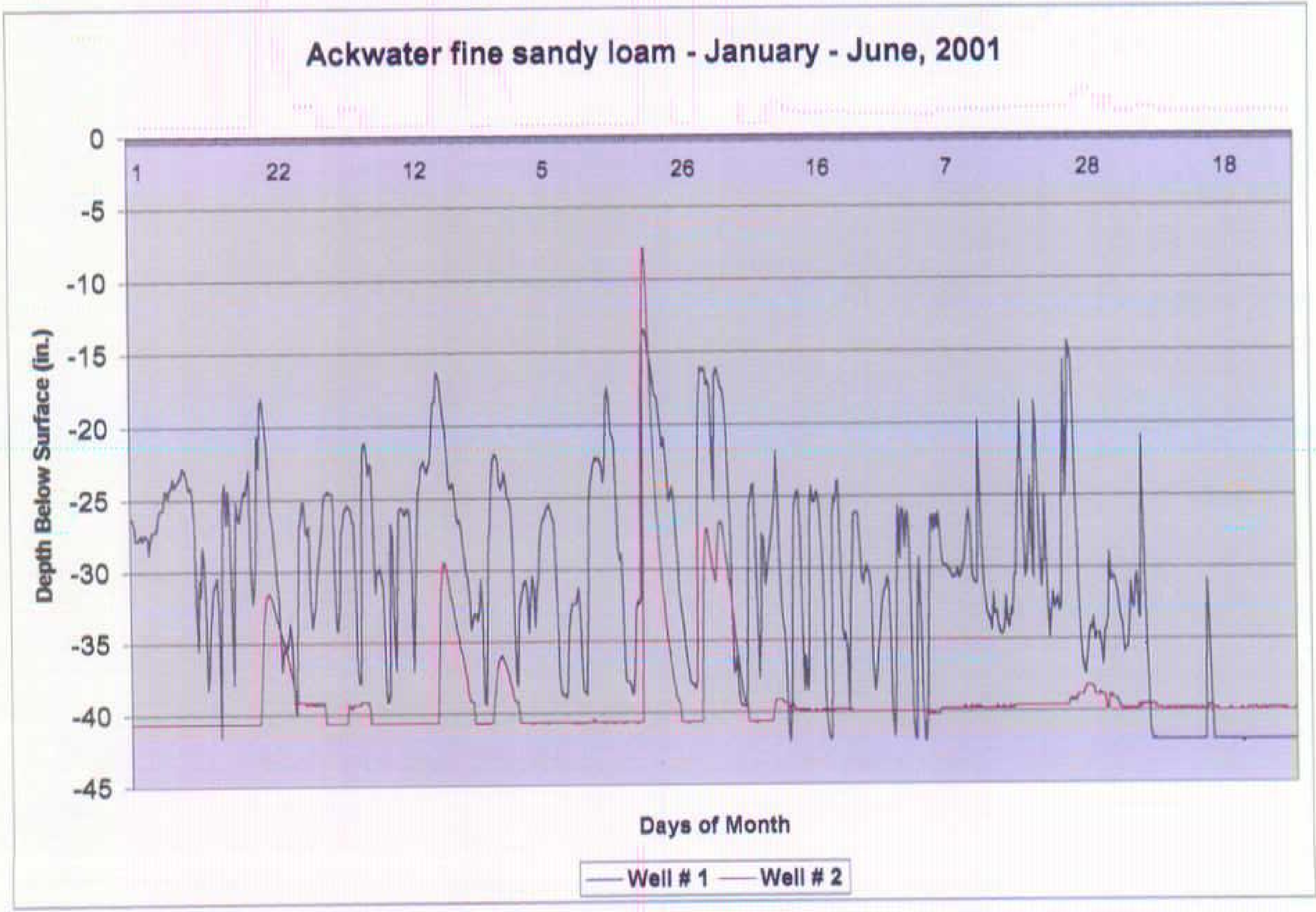


Ackwater fine sand loam - July - December, 1999
Depth Below Surface (in.)
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
1 9 17 25 2 10 18 26 3 11 19 25 29 3 7 11 15 19 23 27 31 4 8 12 16 20 24 28 2 6 10 14 18 22 26 30
Days of Month
Well # 1
Well # 2



Ackwater fine sandy loam - January - June, 2000
Depth Below Surface (in.)
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
1 6 11 16 21 26 31 5 10 15 20 25 1 6 11 16 21 26 31 5 10 15 20 25 30 5 10 15 20 25 30 4 9 14 19 24 29
Days of Month
Well # 1
Well # 2


Ackwater fine sandy loam - July - December, 2000
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
Depth Below Surface (in.)
1 6 11 16 21 26 31 5 10 15 20 25 30 4 9 14 19 24 29 4 9 14 19 24 29 3 8 13 18 23 28 3 8 13 18 23 28
Days of Month
Well # 1
Well # 2


Ackwater fine sandy loam - January - June, 2001
Depth Below Surface (in.)
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
1
22
12
5
26
16
7
28
18
Days of Month
Well # 1
Well # 2

SOIL EVALUATED: Acredale silt loam

LOCATION:

This research site was located in the southern portion of the City of Virginia Beach, Virginia. Refer to the accompanying portion of the Creeds U.S. Geologic Survey topographic map for the general character of the area. The accompanying detailed site sketch shows the location of two automated WL-40 data loggers on this residential property.

RATIONALE FOR SITE SELECTION:

There Were several reasons for using this site. First, the type of soil at the site, Acredale, represents a major soil type located over large areas in the Cities of Chesapeake and Virginia Beach. To study it would provide valuable information that could apply to numerous sites considered for onsite septic systems. Second, while the Acredale soil meets Virginia criteria to allow installation of a conventional gravity drainfield in the Cities of Chesapeake and Virginia Beach, drainfields in this soil often do not work properly on a year-round basis. And finally, since hydric soils are not used in other parts of the state due to wetland issues, this study could provide information on how well this subsurface septic system works in problem soils.

SOIL_ANDSITEINF,ORMATION:

The soil at this site formed in moderately fine textured, stratified, unconsolidated, fluvio-marine sediments of the lower Coastal Plain. There was a broad, level to nearly level fiat adjacent to the site. The site was also on a broad, level to nearly level fiat. Well # 1 was located in the area of the subsurface conventional drainfleld and Well # 2 was located between the drainfield and the surrounding ditches.

The published Soil Survey of City of Virginia Beach, Vir.qinia, Danny R. Hatch, et. al., September 1985, shows the research site as being mapped as Acredale silt loam (1). Acredale is a poorly drained soil.

A detailed soil profile description was made at the site and is included. When compared to the official soil series description for the Acredale series (refer to the Appendix), the soil at this site falls within the range of characteristics. That means the soil was typical or representative of Acredale soils.

Since the soil was suitable for a conventional gravity drainfield only by current regulations (hydric soil - soil drainage management plan), the subSurface conventional system had septic trenches 18 inches below the surface. These trenches were 3 feet wide and 100 feet long. The drainfield must be surrounded with ditches with inverts at least 6 inches deeper than the invert of the septic trenches. The ditches must be 70 feet plus or minus 10 from the existing drainfield and/or reserve area. The finished drainfield area is to be capped and crowned to encourage surface removal of water from the site.

CLIMATIC DATA FOR THE SITE:

Precipitation was monitored at the site by the homeowner. This current data was compared to the precipitation data published in the Soil Survey of City of Virginia Beach, Virginia referenced above. This precipitation data from the home site was used to evaluate rainfall during the study period. The precipitation comparison graph shows how each month's rainfall total compares to the monthly 29-year average (1949-1978).

It is apparent that 1999 was a very abnormal year. Hurricanes Dennis, Floyd and Irene produced rainfall totals in excess of 33 inches during a six week period from September 3 through October 18. For the March-June period, precipitation was slightly above normal with 1.96 inches above or 115%. For the July-December period, precipitation was dramatically above normal. In fact, rainfall was 189% of the long-term average for that period. Therefore, the water table levels at the site would be expected to be shallower (nearer to the surface) than during a year with normal precipitation.

For the period January-June 2000, total precipitation was 14.7 inches above the 29-year average or~ 173%. That means that.the water table, levels would, be expected to be much above normal at the site.

For the period July-December 2000, monthly rainfall was above normal. Precipitation was 3.35 inches above the 29-year average or 114%. That means that the water table levels would be expected to be above normal at the site.

Fifteen of the twenty two months (March, April, May, June, July, August, September and October 1999, January, April, May, June, July, August and September 2000) had precipitation levels above normal. For the entire study period of March 1999 through December 2000, overall precipitation.was 41.71 inches above the 29-year average or 151%. Water table levels would be expected to be above normal at the site.

RESULTS:

Two automated data loggers were installed at the site on February 19,1999. Wells were installed in the same soil, same landscape position and at the same topographic elevatiOn. Well # 1 was installed within the footprint of an operating conventional subsurface drainfield wastewater system and Well # 2 was installed 58 feet away. Well # 2 was representative of the soil conditions at the conventional subsurface drainfield system site but was remote enough to be unaffected by the wastewater system. There was continuous data collection from the starting date until December 31, 2000 for both Well # 1 and Well # 2.

The Acredal~ soil at this site had a gleyed matrix of light brownish gray (10YR 6/2) with common yellowish red (5YR 5/6) and brownish yellow (10YR 6/6) mottles from 10-12 inches to 18 inches. This Btgl horizon has silt loam textures. The Btg2 is silty clay loam from 18 to 42 inches and grayish brown (2.5Y 5/2) with many yellowish red (5YR 5/6) and brownish yellow (10YR 6/6) mottles. The Btg3 is silty clay from 42 to 48 inches and gray (5Y 5/1) with many yellowish red (5YR 5/6) and brownish yellow (10YR 6/6) mottles. This so'il has restrictive permeability below 18 inches that becomes more restrictive with depth. Acredale is a poorly drained soil. This soil normally has a perched water table.

The water table hydrograph of February- June, 1999 shows the presence of free water in the soil within 12 inches for 12-40 days, 12-18 inches for 49-85 days, 18-24 inches for 83-114 days, 24-30 inches for 96-123 days, 30-36 inches for 104-129 days, 36-40 inches for 109-132 days and dry for 0-23 days. Rainfall for this period was above average or 15.4 inches. March, April, May and June were all above normal in precipitation.

The February - June, 1999 Groundwater Data Table shows that the surface of the free water for Well # 1 was in the Ap horizon 40 days or 30% of the time during this 132 day period, in the Btgl horizon 85 days or 64% of the time and the Btg2 horizon 11.4-132 days or 86-100% of the. time. The. Btg3 horizon was. saturated the entire time. For Well # 2, the surface of the free water was in the Ap horizon 12 days or 9% of the time during this 132 day period, in the Btgl horizon 49 days or 37% of the time and the Btg2 horizon 83-109 days or 63-83% of the time. The Btg3 horizon was dry for 23 days or 17% of the time.

The water table hydrograph of July - December, 1999 shows the presence of free water in the soil within 12 inches for 8-133 days, 12-18 inches for 43-148 days, 18-24 inches for 72-166 days, 24-30 inches for 104-176 days, 30-36 inches for 131-183 days, 36-40 inches for 142-184 days and dry for 0-42 days. Rainfall for this period was dramatically above average or 46.2 inches, precipitation during this six week period of the hurricanes was in excess of 33 inches. July, August, September and October were above normal while November and December were below normal in precipitation.

The July - December, 1999 Groundwater Data Table shows that the surface of the free water for Well # 1 was in the Ap horizon 112-133 days or 61-72% of the time during this 184 day period, in the Btgl horizon 148 days or 80% of the time and the Btg2 horizon 166-184 days or 90-100% of the time. The Btg3 horizon was saturated the entire time. For Well # 2, the surface of the free water was in the Ap horizon 8-24 days or 4-13% of the time during this 184 day period, in the Btgl horizon 43 days or 23% of the time and the Btg2 horizon 72-142 days or 39-77% of the time. The Btg3 horizon was dry for 42 days or 23% of the time.

The water table hydrograph of January - June, 2000 shows the presence of free water in the soil within 12 inches for 11-112 days, 12-18 inches for 93-151 days, 18-24 inches for 135-170 days, 24-30 inches for 156-182 days, 30-36 inches for 166-182 days and saturated below 36 inches for the entire pedod. Rainfall for this period was dramatically above average or 34.8 inches. January, April, May and June were above normal while February and March were below normal in precipitation.

The January - June, 2000 Groundwater Data Table shows that the surface of the free water for Well # 1 was in the Ap hodzon 84-112 days or 46-62% of the time during this 182 day period, in the Btgl hodzon 151 days or 83% of the time and the Btg2 horizon 170-182 days or 94-100% of the time. The Btg3 horizon was saturated 'the entire time. For Well # 2, the surface of the free water was in the Ap horizon 11-47 days or 6-26% of the time during this 182 day period, in the Btgl horizon 93 days or 51% of the time and the Btg2 horizon 135-182 days or 74-100% of the time. The Btg3 horizon was saturated the entire time.

The water table hydrograph of July - December, 2000 shows the presence of free water in the Soil within 12 inches for 17-65 days, 12-18 inches for 66-104 days, 18-24 inches for 90-127 days, 24-30 inches for 112-141 days, 30-36 inches for 128-151 days, 36-40 inches for 152-158 days and dry for 26-32 days. Rainfall for this period was slightly above average or 27.85 inches. July, August and September were above normal while.. October, November. and December were below normal in precipitation. October had no precipitation.

The July - December, 2000 Groundwater Data Table shows that the surface of the free water for Well # 1 was in the Ap horizon 47-65 days or 25-35% of the time during this 184 day period, in the Btgl horizon 104 days or 56% of the time and the Btg2 horizon 127-158 days or 69-86% of the time. The Btg3 hodzon was dry for 26 days or 14% of the time. For Well # 2, the surface of the free water was in the Ap horizon 17-45 days or 9-25% of the time during this 184 day period, in the Btgl horizon 66 days or 36% of the time and the Btg2 hodzon 90-152 days or 49-83% of the time. The Btg3 horizon was dry for 32 days or 17% of the time.

CONCLUSIONS:

This site had precipitation levels above normal for 15 months of the 22 months the study was conducted. Those fifteen months, March, April, May, June, July, August, September and October, 1999; and January, April, May, June, July, August and September, 2000; had totals of 113.95 inches, 53.66 inches above normal. That relates to 189% of normal precipitation for those 15 months. The total study period (22 months) had 124.25 inches. Based on the 29-year average, this relates to 151% of normal precipitation.

Because of dramatically above normal precipitation, free water was present for significant periods of time during the study period at lower depths in the soil. In addition, the depth to free water was much shallower than was expected. Once the water table rose in the soil, it remained for an extended pedod of time.

Free water was observed in the Ap hodzon for short periods of time and was always associated with precipitous rises in the water table. For the entire study period, free water was in this horizon for 0 to 350 days of the total 682 days or 0 to 51 percent of the time, though not continuouSly. There were no soil morphological features that could be related to the presence of water in the soil for the number of days observed, except for thickness.

Free water was observed in the Btgl horizon for 251 to 488 days of the total 682 days during the entire study period and was always associated with sharp rises in the water table. This relates to 37 to 72 percent of the time. Yellowish red (5YR 5~6) and brownish yellow (10YR 6~6) mottles in a gleyed matrix were soil morphological features that could be related to the presence of water in the soil for extended periods of time.

Free water was observed in the Btg2 hodzon for 308 to 472 days of the total 682' days during the entire study period and was always associated with sharp rises in the water table. This relates to 45 to 69 percent of the time. Yellowish red (5YR 5~6) and brownish yellow (10YR 6~6) mottles in a gleyed matrix were soil morphological features that. could be related to the presence, of water in the soil for extended periods of time.

The presence of yellowish red (5YR 5~6) and brownish yellow (10YR 6~6) mottles in a gleyed matrix were redoximorphic features (mottles) that could be related to the presence of water in the soil for some periods of time. During the winter-spring time of the year, the seasonal water table was present in the Btgl horizon for 112 to 3/4 of the time.

It must be remembered that when the surface of the water table was in one of the upper horizons such as the-Btgl horizon, the Btg2 horizon and lower horizons were saturated for longer periods. Free water was observed in the Btg2 horizon for 6/10 to 10/10 of the time. This horizon had yellowish red (5YR 5~6) and brownish yellow (10YR 6~6) redoximorphic features (mottles).

As was noted earlier, this soil met the minimum state requirements for a conventional gravity drainfield based on regulations in contrast to soil morphology. Based on the period studied, it is apparent that the gravel filled trenches (at a depth of 18 inches) for the existing conventional septic system would have been inundated with free water for very long periods of time. Free water was present in the trench area for 142 to 236 days or 45% to 75% of the time during the winter-spring period. Based on the state sewage regulations in effect when the permit was issued, an 18 inch zone of suitable soil beneath the gravel filled trenches would have been required (the "stand-off zone") for treatment and disposal of the wastewater. Based on this research, the seasonal water table would have been in the "stand-off zone" at least 170 to 311 days or 54% to 100% of the time during a winter-spring period. Although soil morphology indicated this soil was unsuitable for a conventional gravity drainfield, the monitoring data taken while there was above normal precipitation showed the soil was unsuitable.

It should be pointed out that the drainfield stayed saturated for a majority of the time. This might be due to the slow permeability of the soil in reference to wastewater input. Prismatic structure does not promote good permeability.

Acredale silt loam

Profile for Well # 1: (WL40)

Ap--0 to 12 inches, dark grayish brown (10YR 4/2) silt loam; weak medium granular structure; very friable, slightly sticky, slightly plastic.

Btgl-12 to 16 inches, light brownish gray (10YR 6/2) silt loam; common medium distinct yellowish red (SYR 5/6) and brownish yellow (10YR 6/6) mottles; weak coarse prismatic structure parting to weak medium subangular blocky structure; friable, slightly sticky, slightly plastic.

Btg2-18 to 42 inches, grayish brown (2.5Y 5/2) silty clay loam; many medium distinct yellowish red (5YR 5/6) and brownish yellow (10YR 6/6) mottles; weak coarse prismatic structure parting to weak medium subangular blocky structure; friable, sticky, plastic.

Btg3-42 to 48 inches, gray (5Y 5/1) silty clay; many medium distinct yellowish red (5YR 5/6) and brownish yellow (10YR 6/6) mottles; weak coarse prismatic structure parting to massive; firm, sticky, plastic.

Remarks: This profile taken from an auger hole.

Profile for Well # 2: (WL40)

Ap--0 to 10 inches, dark grayish brown (10YR 4/2) silt loam; weak medium granular structure; very friable, slightly sticky, slightly plastic.

Btgl-10 to 18 inches, light brownish gray (10YR 6/2) silt loam; common medium distinct yellowish red (5YR 5/6) and brownish yellow (10YR 6/6) mottles; weak coarse prismatic structure parting to weak medium subangular blocky structure; friable, slightly sticky, slightly plastic.

Btg2-18 to 42 inches, grayish brown (2.5Y 5/2) silty clay loam; many medium distinct yellowish red (5YR 5/6) and brownish yellow (10YR 6/6) mottles; weak coarse Prismatic structure parting to weak medium subangular blocky structure; friable, sticky, plastic.

Btg3-42 to 48 inches, gray (5Y 5/1) silty clay; many medium distinct yellowish red (5YR 5/6) and brownish yellow (10YR 6/6) mottles; weak coarse prismatic structure parting to massive; firm, sticky, plastic.

Remarks: This profile taken from an auger hole.

Table I - - Acredale silt loam Groundwater Data Table
February-June, 1999 (132 Days)

	Well # 1				Well # 2			
Depth Range (in.)	Number of Days	Percent Time	Percent Cumulative . Days	Cumulative Days	Number of Days	Percent Time	Cumulative Days	Percent Cumulative Days
0-6	0	0	0	0	0	0	0	0
6.1-12	40	30	40	30	12	9	12	9
12.1-18	45	34	85	64	37	28	49	37
18.1-24	29	22	114	86	34	26	83	63
24.1-30	9	7	123	93	13	10	96	72
30.1-36	6	5	129	98	8	6	104	79
36.1-40	3	2	132	100	5	4	109	83
Dry	....				23	17	132	100 .

Table 2 - - Acredale silt loam Groundwater Data Table
July-December, 1999 (184 Days)

	Well # 1				Well # 2			
Depth Range (in.)	Number of Days	Percent Time	Percent Cumulative Days	Cumulative Days	Number of Days	Percent Time	Cumulative Days	Percent Cumulative Days
0-6	112	61	112	61	8	4	8	4
6.1-12	21	11	133	72	16	8	24	13
12.1-18	15	8	148	80	19	10	43	23
18.1-24	18	10	166	90	29	16	72	39
24.1-30	10	6	176	95	32	18	104	56
30.1-36	7	3	183	99	27	15	131	71
36.1-40	1	1	184	100	11	6	142	77
Dry	......				42	23	184	100

Number of Days column refers to the number of days the surface of the free water was present within the depth range.

Percentage of Time column refers to the percent of time the water was present within the depth range.

Cumulative Days column refers to the total number of days the water was present within the depth range.

Percentage of Cumulative Days refers to the percent of total time the water was present within the depth range.

DRY corresponds to the number of readings (converted to days) where the monitoring well recorded no water in the hole.

Days in the column headings corresponds to the number of data logger readings within a depth range divided by the number (normally 2, 4 or 8) of data logger readings per day.

Table 3 - - Acredale silt loam Groundwater Data Table
January-June, 2000 (182 Days)

	Well # 1				Well # 2			
Depth Range (in.)	Number of Days	Percent Time	Cumulative Days	Percent Cumulative Days	Number of Days	Percent Time	Cumulative Days	Percent Cumulative Days
0 - 6	84	46	84	46	11	6	11	6
6.1-12	28	16	112	62	36	19	47	26
12.1-18	39	21	151	83	46	25	93	51
18.1-24	19	11	170	94	42	23	135	74
24.1-30	12	6	182	100	21	12	156	86
30.1-36	....				10	6	166	91
36.1-40	....				16	9	182	100
Dry	....							

Table 4 - - Acredale silt loam Groundwater Data Table
July-December, 2000 (184 Days)

	Well # 1				Well # 2			
Depth Range (in.)	Number of Days	Percent Time	Cumulative Days	Percent Cumulative Days	Number of Days	Percent Time	Cumulative Days	Percent Cumulative Days
0 - 6	47	25	47	25	17	9	17	9
6.1-12	18	10	65	35	28	15	45	25
12.1-18	39	21	104	56	21	12	66	36
18.1-24	23	12	127	69	24	13	90	49
24.1-30	14	8	141	76	22	12	112	61
30.1-36	10	6	151	82	16	9	128	70
36.1-40	7	4	158	86	24	13	152	83
Dry	26	14	184	100	32	17	184	100

Number of Days column-refers to the number of days the surface of the free water was present within the depth range.

Percentage of Time column refers to the percent of time the water was present within the depth range.

Cumulative Days column refers to the total number of days the water was present within the depth range.

Percentage of Cumulative Days refers to the percent of total time the water was present within the depth range.

DRY corresponds to the number of readings (converted to days) where the monitoring well

recorded no water in the hole.

Days in the column headings corresponds to the number of data logger readings within a depth range divided by the number (normally 2, 4 or 8) of data logger readings per day.

City of Virginia Beach
Acredale Silt Loam
Scale: 1"= 40'

Property line & open ditch

I

House

Subsurface
Drainfield

' 77' 80 o

Data Logger #1 ©-~ 58', 60'

N~-40 Data; Logger #2 ('"3

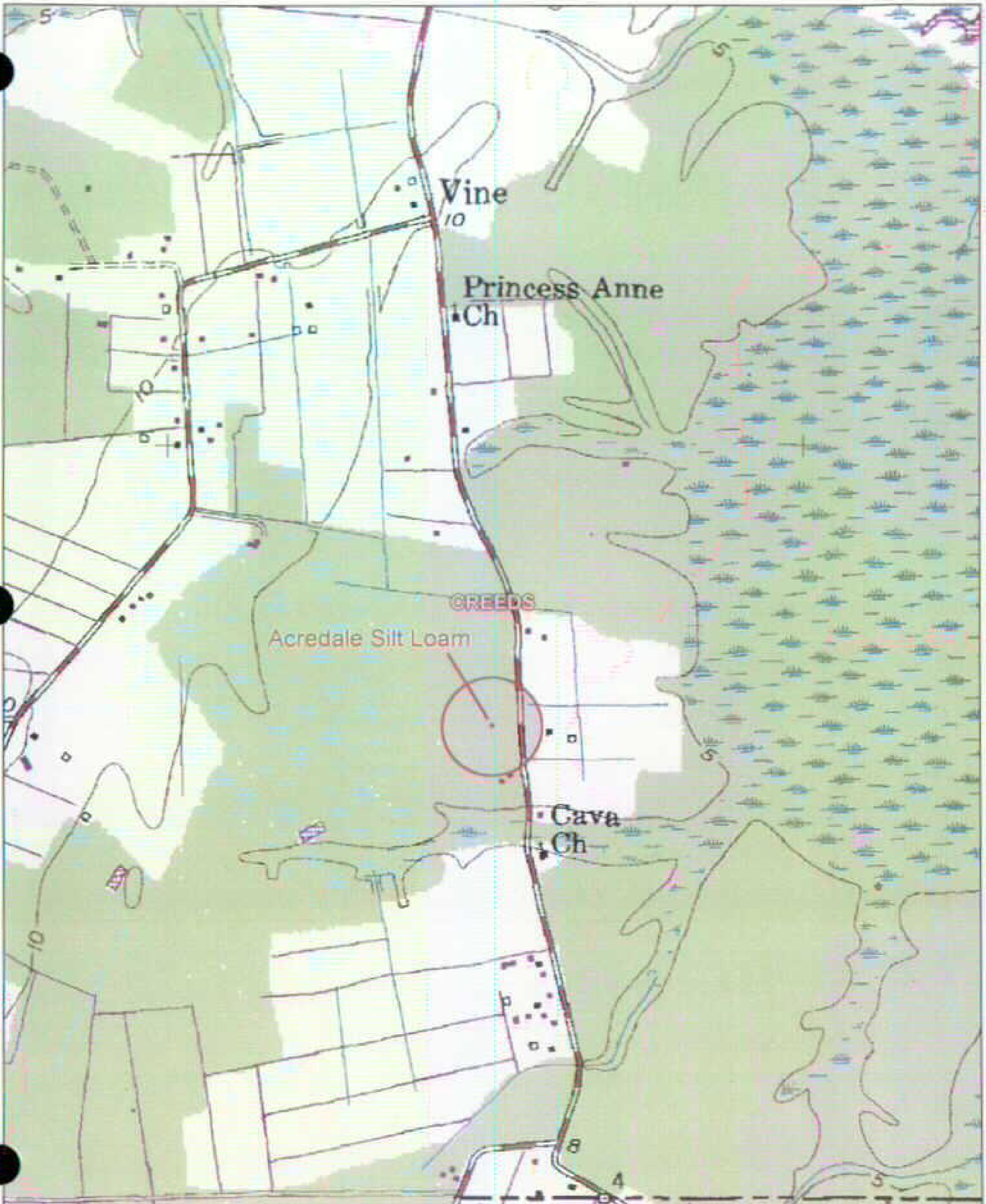
~L-40 O~,_

162'

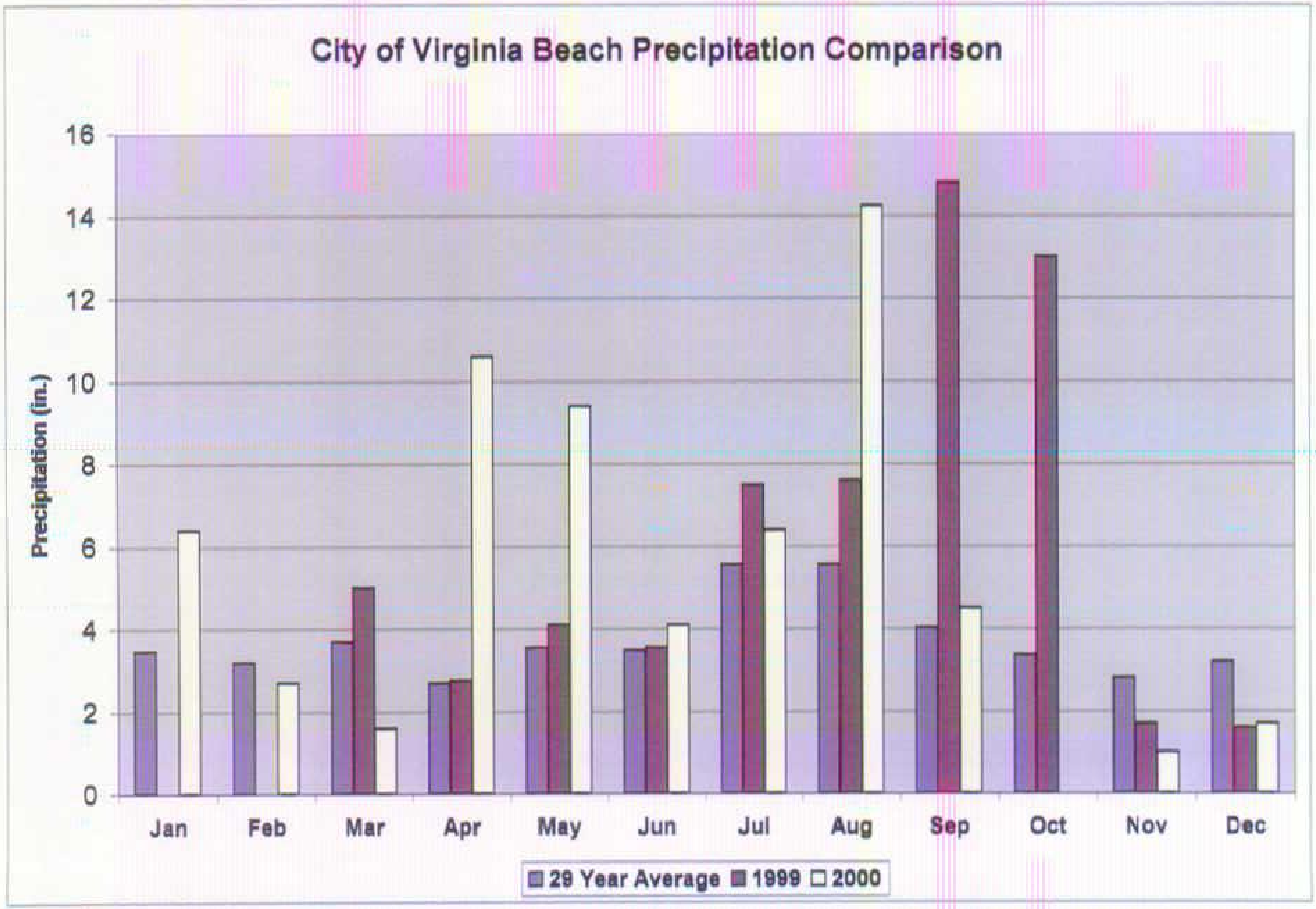
Open ditch

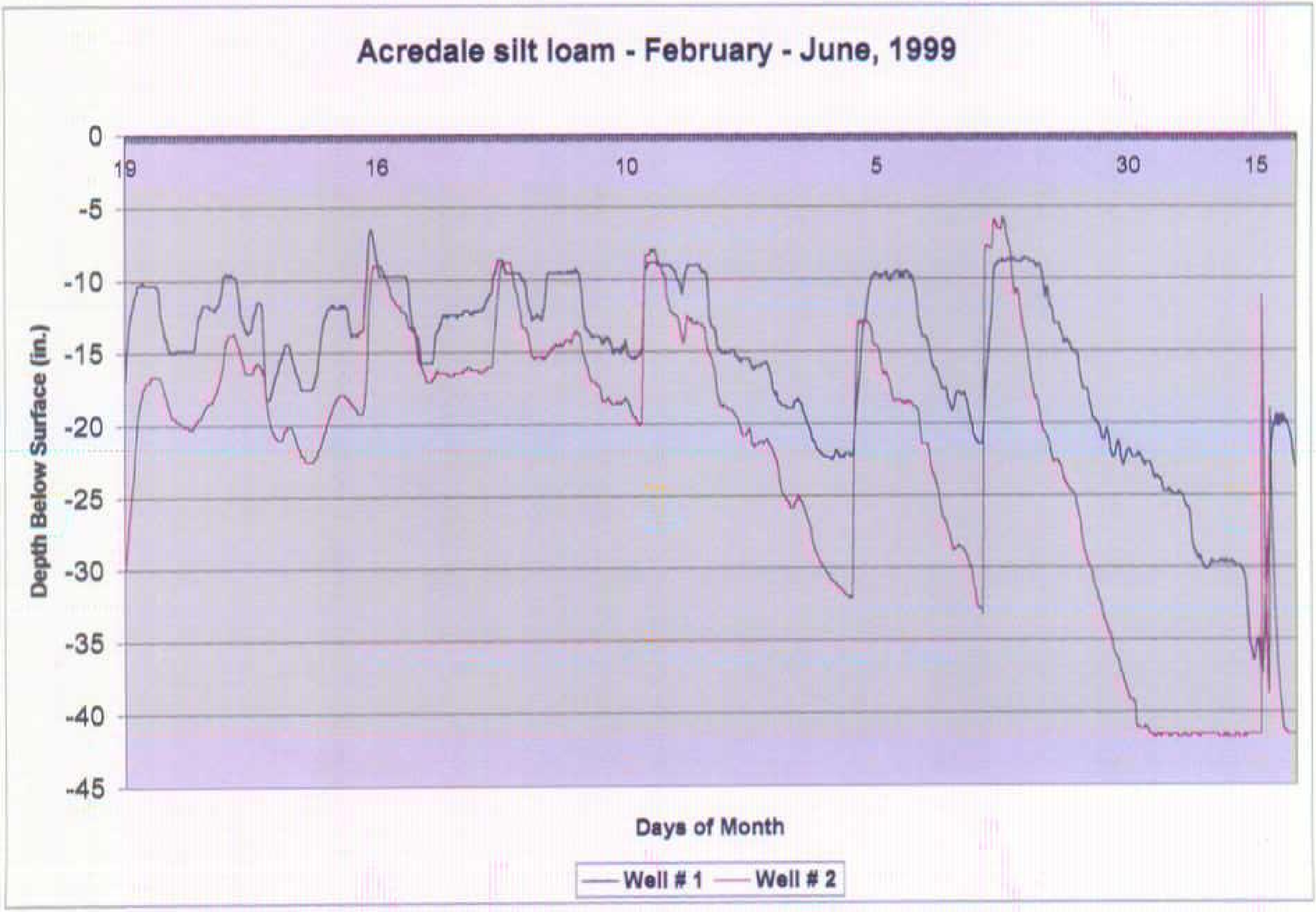
2'10' 24'1

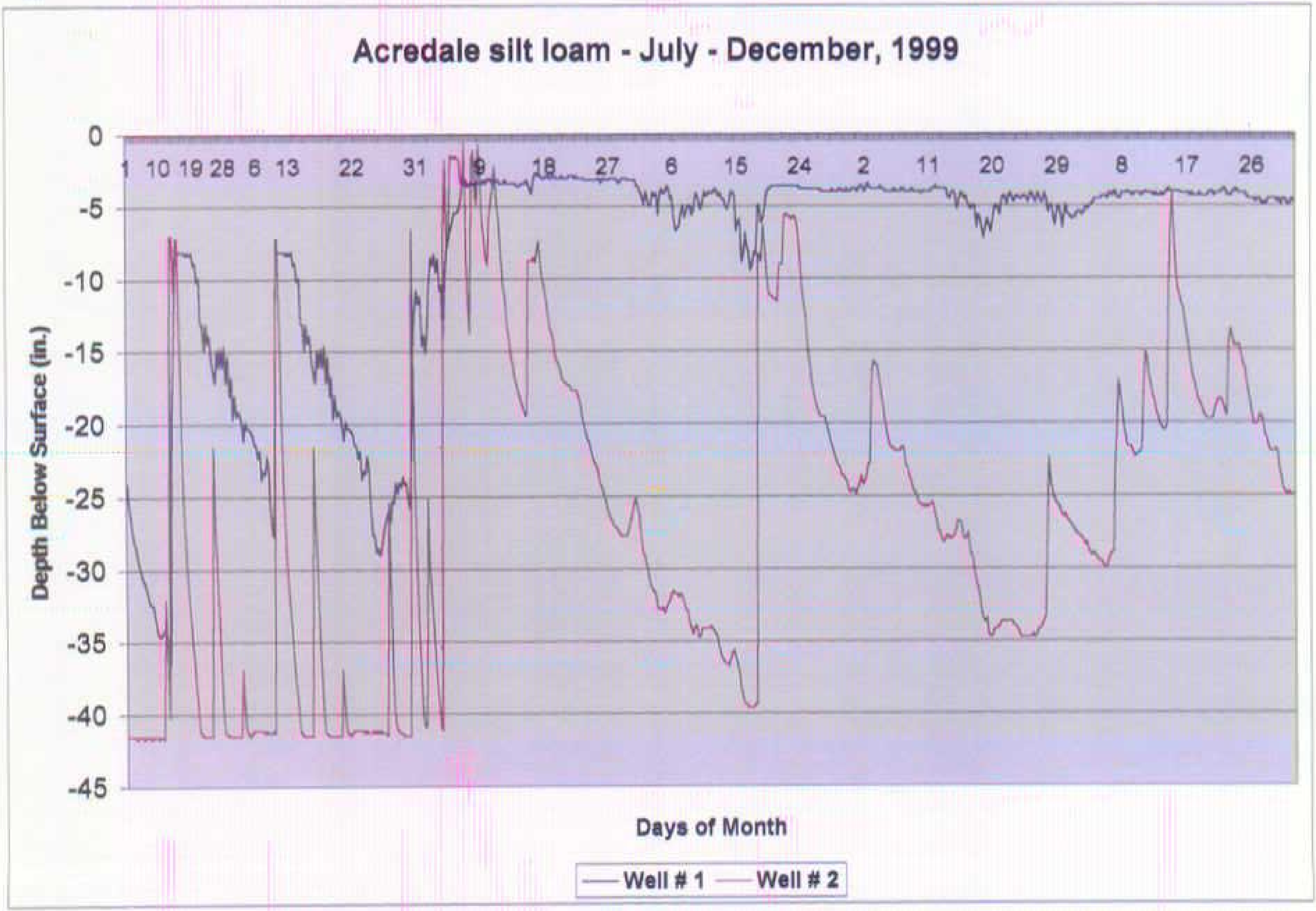
Blackwater Road



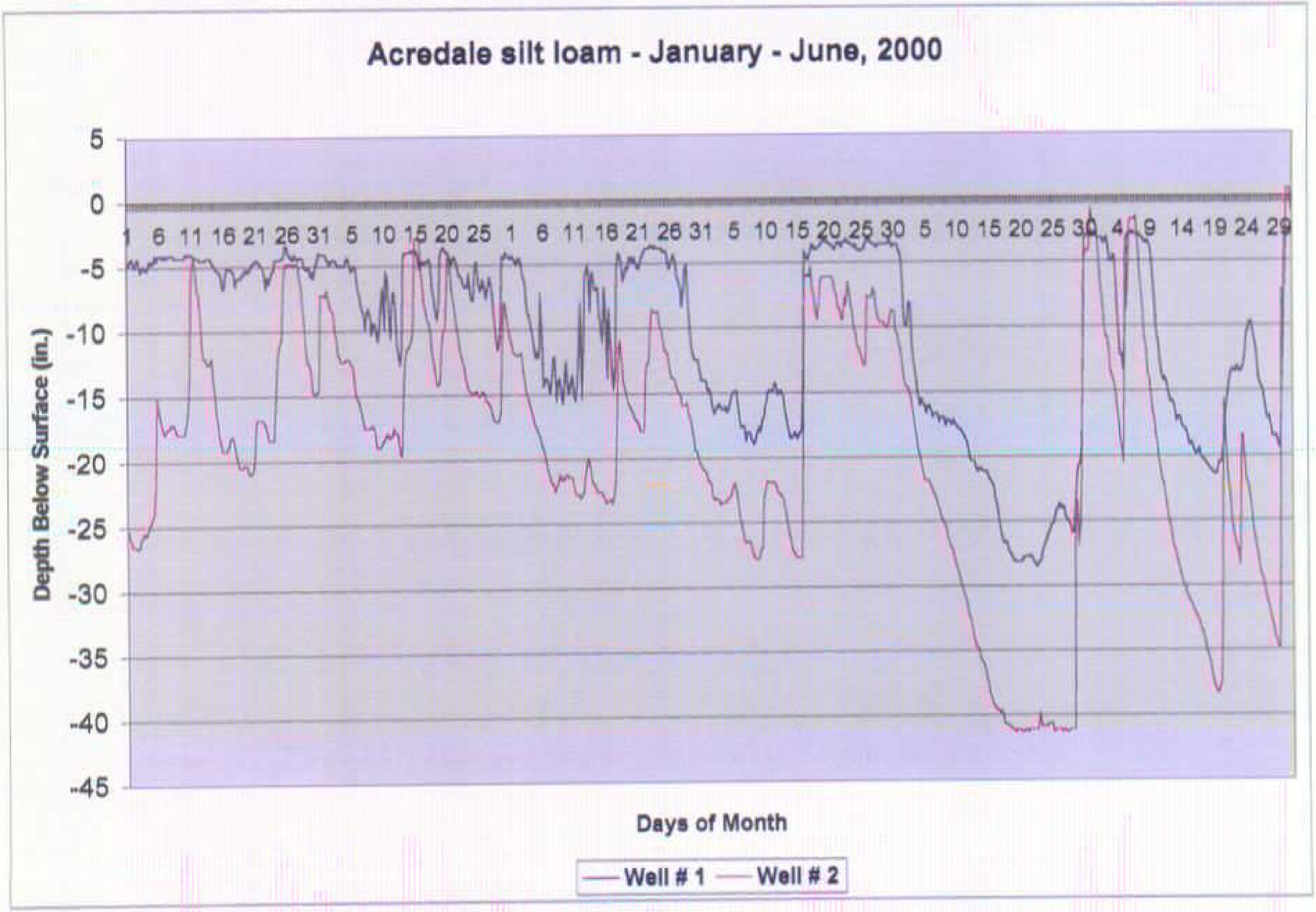
 550 ft Scale: 1 : 12,000 Detail: 14-0 Datum: WGS84


City of Virginia Beach Precipitation Comparison
Precipitation (in.)
16
14
12
10
8
6
4
2
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
29 Year Average
1999
2000

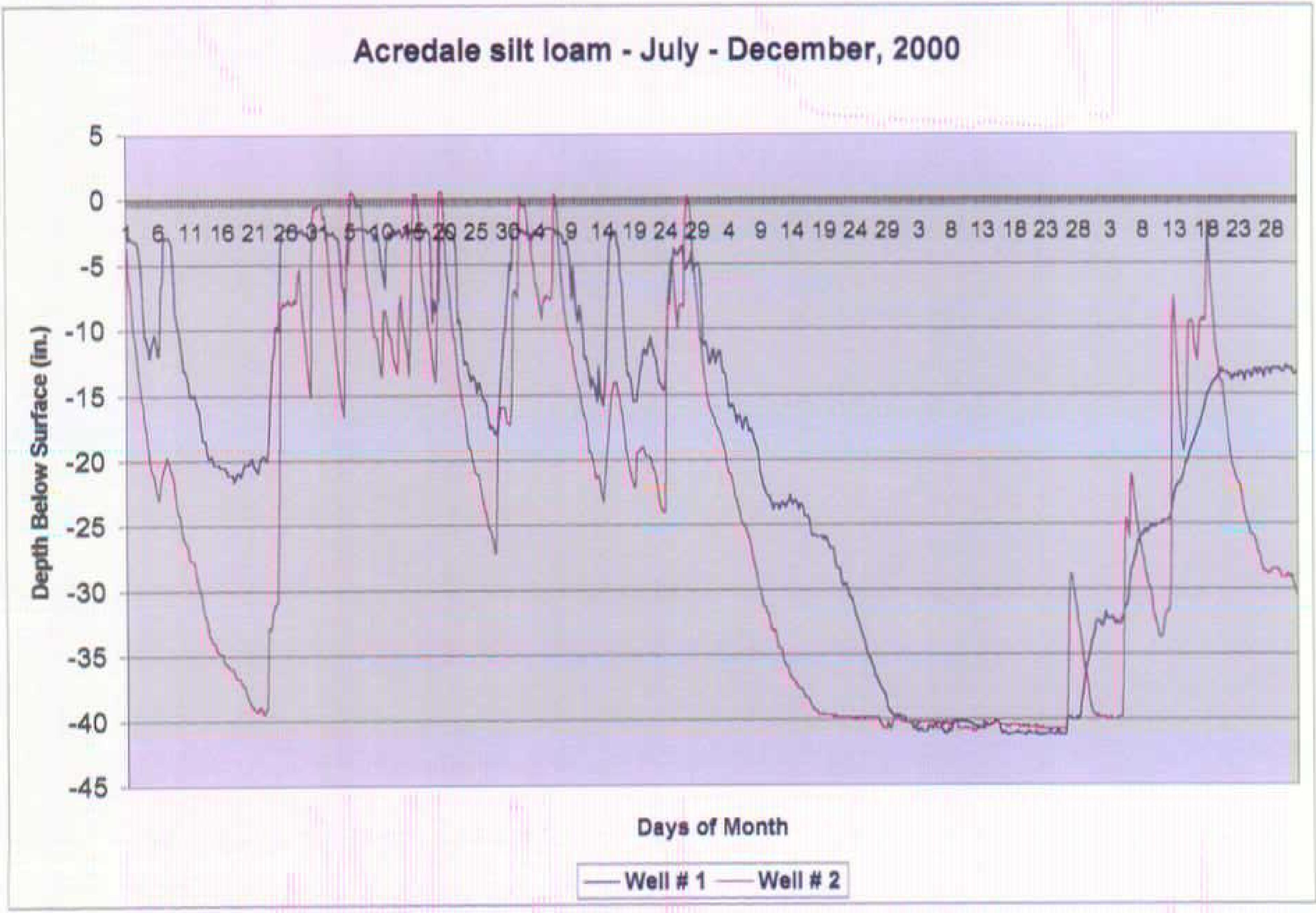

Acredale silt loam - February - June, 1999
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
Depth Below Surface (in.)
19
16
10
5
30
15
Days of Month
Well # 1
Well # 2



Acredale silt loam - July - December, 1999
Depth Below Surface (in.)
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
1 10 19 28 6 13 22 31 9 18 27 6 15 24 2 11 20 29 8 17 26
Days of Month
Well # 1
Well # 2



Acredale silt loam - January - June, 2000
Depth Below Surface (in.)
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
1 6 11 16 21 26 31 5 10 15 20 25 1 6 11 16 21 26 31 5 10 15 20 25 30 5 10 15 20 25 30 4 9 14 19 24 29
Days of Month
Well # 1
Well # 2


Acredale silt loam - July - December, 2000
Depth Below Surface (in.)
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
1 6 11 16 21 26 31 5 10 15 20 25 30 4 9 14 19 24 29 4 9 14 19 24 29 3 8 13 18 23 28 3 8 13 18 23 28
Days of Month
Well # 1
Well # 2

SOIL EVALUATED: Cotaco silt loam

LOCATION:

This research site was located in the northern section of Roanoke County, Virginia. Refer to the accompanying portion of the U.S. Geologic Survey Salem topographic map for the general character of the area. The portion of the topographic map shows the location of a WL-40 series automated data logger.

RATIONALE FOR SITE SELECTION:

There were several reasons for using this site. First, during the past several years several consultants have submitted this property as suitable for an onsite system only to have the local health department reject their proposals. One of the consultants during the summer months noted the "dryness of the site" after rain events as being proof of suitability for an onsite system. Second, the county EHS and myself thought we were interpreting the soil mottles correctly and the data logger information would provide a second opinion. Third, manganese and more importantly soft manganese nodules that were easily crushed with little finger pressure were present. I interpret soft manganese as being an indicator of current soil conditions, believing the soft masses are better as indicators than the firm masses or concretions. Fourth, with accurate readings of actual water table depths, tbe possibility of using a new alternative system for the site improves.

SOIL AND SITE INFORMATION:

The soil at this site formed in moderately fine textured alluvial and colluvial material derived from sandstone, shale and siltstone. Cotaco soils are found on Iow stream terraces or Iow colluvial benches. This site was located on a long. footslope about 70 feet from a small stream. The site has a large watershed upslope of the well installation. A WL-40 series automated data logger was installed in pine woods with honeysuckle undergrowth.

The published soil survey, Soil Survey of Roanoke County and the Cities of Roanoke and Salem, Virginia, E. P. Ealy, Jr., et al., 1997, shows the research site as being mapped as Weikert-Berks complex. Cotaco soils are moderately well drained and deeper to rock than Weikert soils. So this site was an inclusion in the mapping unit and thought to be closer to the Cotaco series.

An auger soil profile description was made at the site and is included. When compared to the official soil series description for the Cotaco series (refer to the Appendix), the soil at this site may fall within the range of characteristics, with the possible exception of clay content. That means the soil was typical or representative of Cotaco soils.

While the soil was not suitable for a conventional gravity drainfield, there was hope of finding a possible alternative type system using the water table information produced by the data logger.

CLIMATIC DATA FOR THE SITE:

The site was less than 7 miles from the Roanoke Regional Airport, where official NOAA weather data were Collected, so precipitation data from the airport was' used to evaluate rainfall during the study period. The precipitation comparison graph shows how each months rainfall total compares to the monthly 29-year averages (1961-1990).

It is apparent that for the October-December 1999 period, precipitation was Well below normal. In fact, rainfall was only 57% of the long-term average for that three month span. For the year of 1999, precipitation totaled 30.9 inches, or 77% of normal, compared to long term average of 39.8 inches. Therefore, the water table levels at the site would be expected to be shallower (nearer to the surface) during a fall with normal precipitation.

For the period January-June 2000, total precipitation was only I -inch belOw the 29-year average. That means that the water table levels would be expected to be representative of normal conditions at the site if it had not been for the dryness of 1999.

Eor the period July-December 2000, monthly rainfall was 4.5 inches or 11% below normal. It is noteworthy that only 0.01 inches of rain was recorded for the entire month of October 2000, making it the driest October since data collection began at the Roanoke Regional Airport. The October-December 2000 period was extremely dry. In fact, rainfall was only 41% of the long-term average for that 3 month span. That dry fall situation was very similar to moisture conditions noted for the October-December 1999 period. Therefore, the water table levels at the site would be expected to be much shallower during a fall with normal precipitation. The years of 1999 and 2000 were dry and the water tables were depressed or lowered by the drought conditions.

For the period January-April 2001, monthly rainfall was generally below normal. Therefore, the water table levels at the site would be expected to be shallower during a winter and spring with normal precipitation.

Except for a few exceptional wet months the overall precipitation situation was one of below normal to near drought conditions. It should be noted that the original project completion date was extended due to severe drought conditions in most of the state during 1999. The year 2000 was well below normal. Therefore, 1999 the year proceeding the study period; the year 2000 and the first few months of the 2001study period had significantly below normal rainfall. In reality there was insufficient rainfall to recharge the water tables at the site.

RESULTS:

An automated WL-40 data logger was installed on this site on February 11, 2000. The well was installed in the area proposed by the consultants. The well site was representative of the soil conditions at the site. There was continuous data collection from the starting date until Apdl 2001.

The Cotaco soil at this site had common light brownish gray (2.5Y 6/2) mottles (or iron depletions) below 7 inches in the Bt1 horizon. In the A, E and Bt1 horizons soft manganese masses were present. Olive yellow (2.5Y 6/6) mottles were also present in the E and Bt1 and Bt2 horizons. Normally, it would be assumed that the seasonal water table would be below 7 inches, while there might be brief periods where it was above that depth. Several soil descriptions did not list the grays until a deeper depth and some descriptions had chroma 3 mottles instead of chroma 2 mottles. These soils probably have both types of water tables; perched and one that rises from the lower depths.

The horizons between the depths of 18 inches and 54 inches had clay loam and clay textures. Each horizon had a consistence described as very firm. Very firm clay and clay loam horizons would be considered restrictive to downward water movement through the soil profile. The mottling at shallower depths in the E and 13tl horizons was suspected to be associated with the fluctuating seasonal water table. During the augering process the profile was described as difficult to auger between the depths of 18 and 54 inches.

A quick review of the hydrograph for February-June, 2000 shows the level of the water table. The last three months of 1999 and the first three months of 2000 were very dry, with only 63% of normal precipitation. The graph depicts some water ponding or presence above the surface. I have witnessed ponded water at this site on several occasions.

With normal rainfall or above average rainfall the water would have pushed any septic effluent to the soil surface. Any time the VDH is considering a site wetter than normal this information would suggest requiring a pretreatment type system.

The Cotaco Groundwater Data Table lists the water table levels being present within the 0-6 inch depth for 28 days. And in the 12-18 inch depth range where drainfleld trenches are normally installed, a total of 82 days of water table presence was indicated. Again the last three months of 1999 were dry. January, a normally wet month was also dry. If that time period had experienced normal precipitation the water table would probably have been within normal installation depth for over 100 days. Lower than normal precipitation and a rapid drop in the free water level starting in eady May corresponds to shrubs and trees leafing-out and a rapid increase in the evapotranspiration rate at the site. The recorded levels by the data logger dropped for part of May and all of June, except for a few spikes of rapid water table rise and fall.

The February-June 2000 Groundwater Data Table showed that free water was in the installation and separation distances (36 inches) for 114 of the 142-day study period. The seasonal water table was shallower than the depth to gray mottles at least 20% of the time for this monitoring period. The reality was that for February 'thru mid-May, the seasonal water table was nearly always shallower than the depth to gray mottles in the soil.

The July-December 2000 hydrograph shows predominately dry hole readings, from July thru December. There were brief rapid rises in the water table in July, August and Septemb'er and then the hole remained dry until the end of the year. However, because of dry conditions in October thru December 2000, the brief spikes did not rise to as shallow a soil depth or remain shallow for as long a period as during the normal wet winter and spring months.

The July-December 2000 Groundwater Data Table showed that free water was within the 36-inch installation and standoff depths for 19 days. During the dry months the water table was present only 17% of the time it had been present during the first part of the year. With lower precipitation totals the water table remained depressed. During the last 1/4 of the year the water table was always thirty inches deeper than the depth to gray mottles in the soil.

The January-April 2001 hydrograph shows mainly dry hole readings in early January. In mid to late January there was one large spike with water rising to 10 'inches below the surface. After that water levels slowly descended to the 35-inch level and remained near that depth until late March. In late March a sharp spike' raised water table levels above the soil surface. Water levels remained above ten inches into April when the study ended. There were three spikes or rises in the free water table level during the 93-day period.

Free water was only bdefly present in the Bt1 horizon during the three sharp rises in the water table during the 93-day period. Water was in the Bt1 horizon about 16 days, or 19% of the time during this 93-day period. The upper depths of the Bt2 had a similar wetness period. Only when one examines the data at the 30 to 36 inch depth was there a significant increase in the number of wet days. The water table was in the lower Bt2 horizon 74 days or 80% of the time. This depth would correspond to part of the separation distance required if a normal installation depth of 18 inches would have been considered at this site.

CONCLUSIONS:

This site had precipitation levels well below normal for the majority of the study period. In spite of that, there was free water present for significant periods of time during the winter and spring. In addition, during summer months the depth to free water was often much deeper than where gray mottles were observed in the soil. Once the water table rose in the soil, it stayed up for an extended period of time during winter months.

Free water was observed in the E and Bt1 horizons for extended periods of time during the winter months. In the February to June 2000 period water was present 82 days in the 12 to 18 inch depth range. If data had been collected in January, the data could have had an extra 20 to 30 days added to the total. There were soil morphologic features that could be related to the presence of water in the soil for the period observed. Under normal precipitation it would be expected that the seasonal water table would be in the E and Bt1 horizons for Significantly longer periods of time.

In other words, the clues present at this site were often overlooked. Several of the profiles had pale mottles, 2.5Y hue colors and the presence of soft manganese masses. Soft manganese masses are a strong indicator of active water tables. Hard manganese concretions may represent water tables of an older weather period.

The yellow mottles in the E and Bt1 horizons suggest fluctuating water table levels. The light brownish gray (2.5Y 6/2) mottles appearing in the Bt1 horizon from 7 to 18 inches are a clue to the soil wetness or water table levels. Reviewing the February-June 2000 hydrograph or corresponding groundwater table for that period, 54 days of the 142-day period had water levels between 7 and 18 inches. If January data were available many additional "number and cumulative" days would probably be added to the total wet days for that February-June time period. If the January data were available even shallow placement type systems would probably be eliminated from consideration for this site.

Any type of system considered for such sites should at a minimum require pretreatment because the wastewater from the system will be pushed or carried back to the surface by the rising water tables during years with near normal precipitation levels. As techn(~logy improves in the future a satisfactory system design may become available for such wet sites.

The location of this site was on a Iow bench or'terrace on a long footslope, with a large upslope watershed, that contributed to how wet the soil was. During the winter-spring periods when plants were dormant and exapotranspiration was very Iow, groundwater not held in the soil moved downslope towards this site.

As was noted earlier, this soil did not meet the minimum state requirements for a conventional gravity drainfield, based on soil morphology and landscape position. Yet the location has had drainfleld proposals submitted to the local VDH by consultants. From the .groundwater tables and hydrographs presented, it is apparent that if a conventional septic system had been installed, the gravel filled trenches (at a depth of 18 inches) would have been inundated with free water for long periods of time leading to quick failures. Based on this research, the seasonal water table would have been in the "stand-off zone" at least 1/2 to 3/4 of the time during a winter-spring period. Soil morphology indicated this soil was not suitable for a conventional gravity drainfield and fifteen months of monitoring data taken while there was below normal precipitation, showed the soil was unsuitable.

In reality the VDH should require the use of water table studies from December through May for sites that appear to have water table features as distinguished by soil morphology clues. Dudng the drier summer and fall months the water table sometimes drops enough and may not be a concern. In other words the critical time for water table levels to be noted is during the wet part of the year or winter months.

The Virginia Department of Health should adhere to the proven soil morphology 'clues to determine water table levels unless water table studies are conducted during normal precipitation levels. The department needs to redefine the use of manganese as a water table clue. If soft manganese masses are present, an active water table is present. If hard concretions are present then maybe the upper end of common (2 to 20%) or many (>20 %) concretions should be required as proof. Many good soils in Virginia, in the Piedmont and Limestone Valleys have manganese concretions present high in the profile and are situated on steep slopes where water tables are not present.

Cotaco silt loam

Profile for Well # 1 (WL20)

A--0 to 2 inches, dark brown (10YR 4/3) silt loam; moderate fine granular structure.

E--2 to 7 inches; light yellowish broWn (2.5Y 6/4) sandy clay loam; yellow (2.5Y 7/6) mottles; weak fine blocky structure; slightly firm; .5 inch soft manganese masses; saturated.

Bt1--7 to 18 inches, light yellowish brown (2.5Y 6~4) sandy clay loam; light brownish gray (2.5Y 6/2) and olive yellow (2.5Y 6/6) mottles; firm; .5 inch soft manganese masses and stains; 2% rock fragments, saturated.

Bt2--18 to 41inches; mottled; light brownish gray (2.5Y 6/2), gray (10YR 5/1), yellowish brown (10YR 5/6), yellow (2.5Y 7/6), clay loam; very firm; 5% percent rock fragments, manganese concretions, hard to auger.

Bt3--41 to 48 inches, mottles; light brownish gray (2.5Y 6/2), gray (10YR 5/1), yellow (2.5Y 7/6), yellowish brown (10YR 5/6), clay; very firm, manganese concretions, 5% rock fragments; hard to auger, soil tears apart.

Cg--48 to 54 inches, gray (10YR 5/1) light brownish gray (2.5Y 6/2) clay; very firm, manganese concretions, hard to auger, soil tears apart.

Soil may be massive in structure below 18 inches. Difficult to auger between 18 and 54 inches. Water fills the auger hole almost to the surface immediately after augering. Water was perching between the soil surface and eighteen inches.

Remarks: This profile description taken from an auger hole located in a stand of' pine trees with honeysuckle underbrush.

Table 1 - - Cotaco silt loam Groundwater Data Table
February - June, 2000 (142 Days)
Bennet Springs, Data Logger Well # 1

Well # 1

Depth Range (in.)	Number of Days	Percent Time	Cumulative Days	Percent Cumulative Days
0 - 6	28	20	28	20
6.1-12	27	20	55	39
12.1 -18	27	20	82	58
18.1-24	10	7	92	65
24.1-30	9	6	101	70
30.1-36	13	10	114	80
36.1-39.8	20	14	134	94
39.9.43.6(Dry)	8	6	142	100

Table 2 - - Cotaco silt loam Groundwater Data Table
July - December, 2000 (184 Days)
Bennet Springs, Data Logger Well # 1

Well # 1

Depth Range (in.)	Number 'of Days	Percent Time	Cumulative Days	Percent Cumulative Days
0-6	0	0	0	0
6.1-12	0	0	0	0
12.1-18	I	1	1	1
18.1-24	3	2	4	2
24.1-30	4	2	8	4
30.1-36	11	6	19	10
36.1-39.7	39	21	58	32
39.8-41.8(Dry)	126	68	184	'100

Number of Days column refers to the number of days the surface of the free water was present within the depth range.
Percentage of Time column refers to the percent of time the water was present within the depth range.
Cumulative Days column refers to the total number of days the water was present within the depth range.
Percentage of Cumulative Days refers to the percent of total time the water was present within

the depth range.
DRY corresponds to the number of readings (converted to days) where the monitoring well recorded no water in the hole.
Days in the column headings corresponds to the number of data logger readings within a depth range divided by the number (normally 2, 4 or 8) of data logger readings per day.

Table 1 - - Cotaco silt loam Groundwater Data Table

January - April, 2001 (93 Days)

Bennet Springs, Data Logger Well # 1

Well # 1

Depth Range (in.)	Number of Days	Percent Time	Cumulative Days	Percent Cumulative Days
0-6	7	6	7	6
6.1-12	5	5	12	13
12.1-18	4	4	16	19
18.1-24	1	1	17	19
24.1-30	8	9	25	27
30.1-36	49	54	74	80
36.1-39.8	2	2	76	82
39.9-41.4(Dry)	17	19	93	100

Number of Days column refers tothe number of days the surface of the free water was present within the depth range.

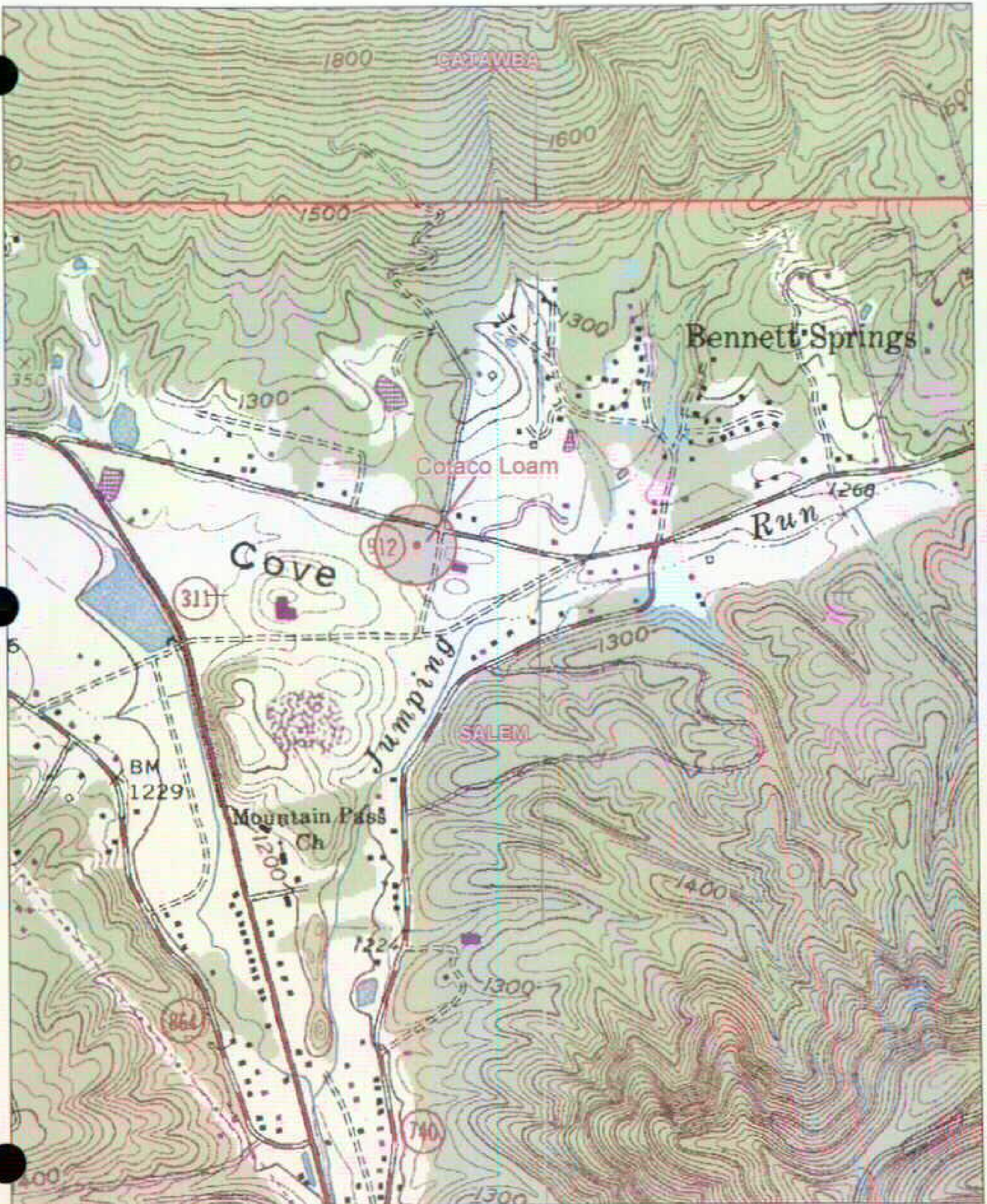
Percentage of Time column refers to the percent of time the water was present within the depth range.

Cumulative Days column refers to the total number of days the water was present within the depth range.

Percentage of Cumulative Days refers to the percent of total time the water was present within the depth range.

DRY corresponds to the number of readings (converted to days) where the monitoring well recorded no water in the hole.

Days in the column headings corresponds to the number of data logger readings within a depth ran. ge divided by the number (normally 2, 4 or 8) of data logger readings per day.



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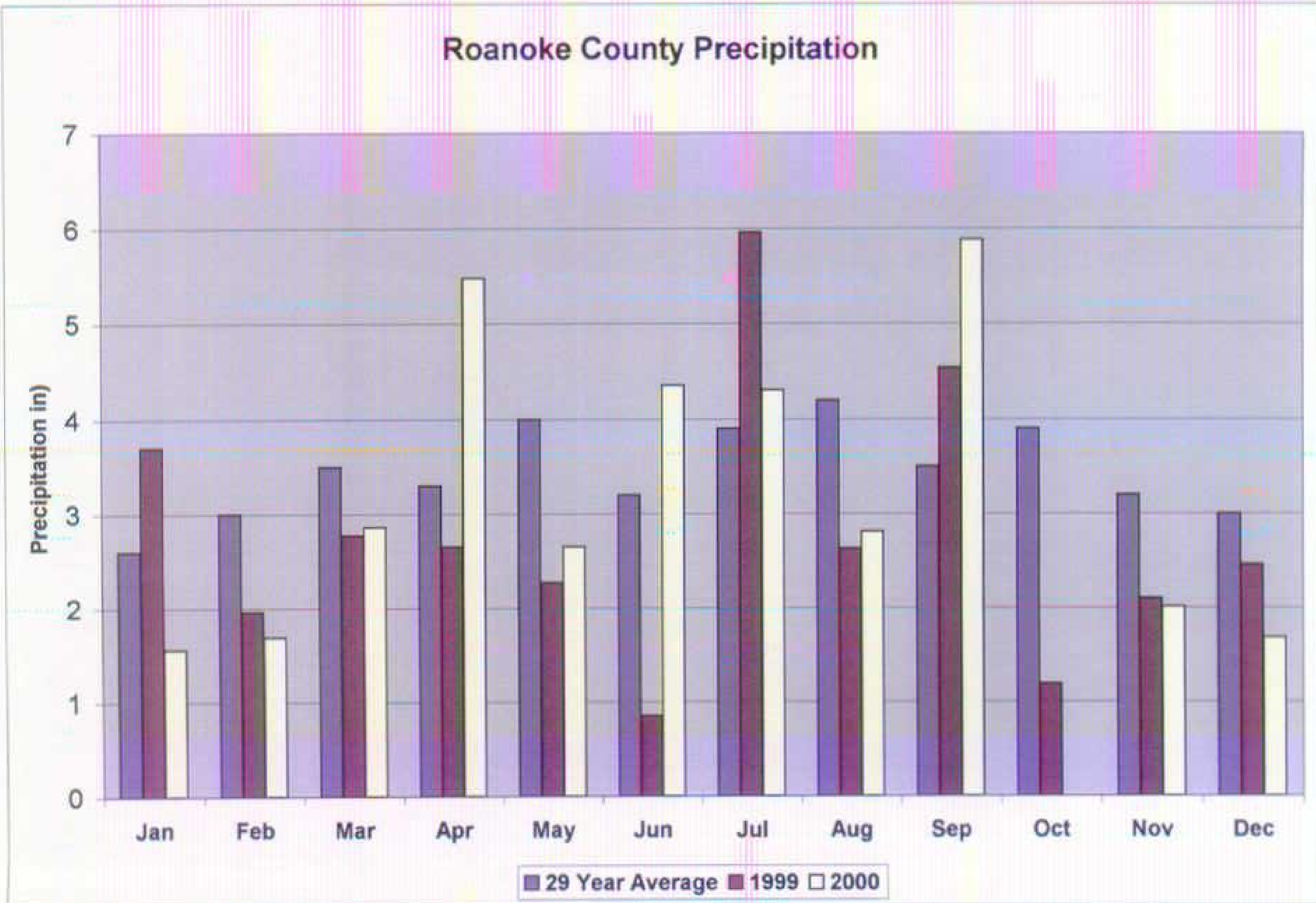
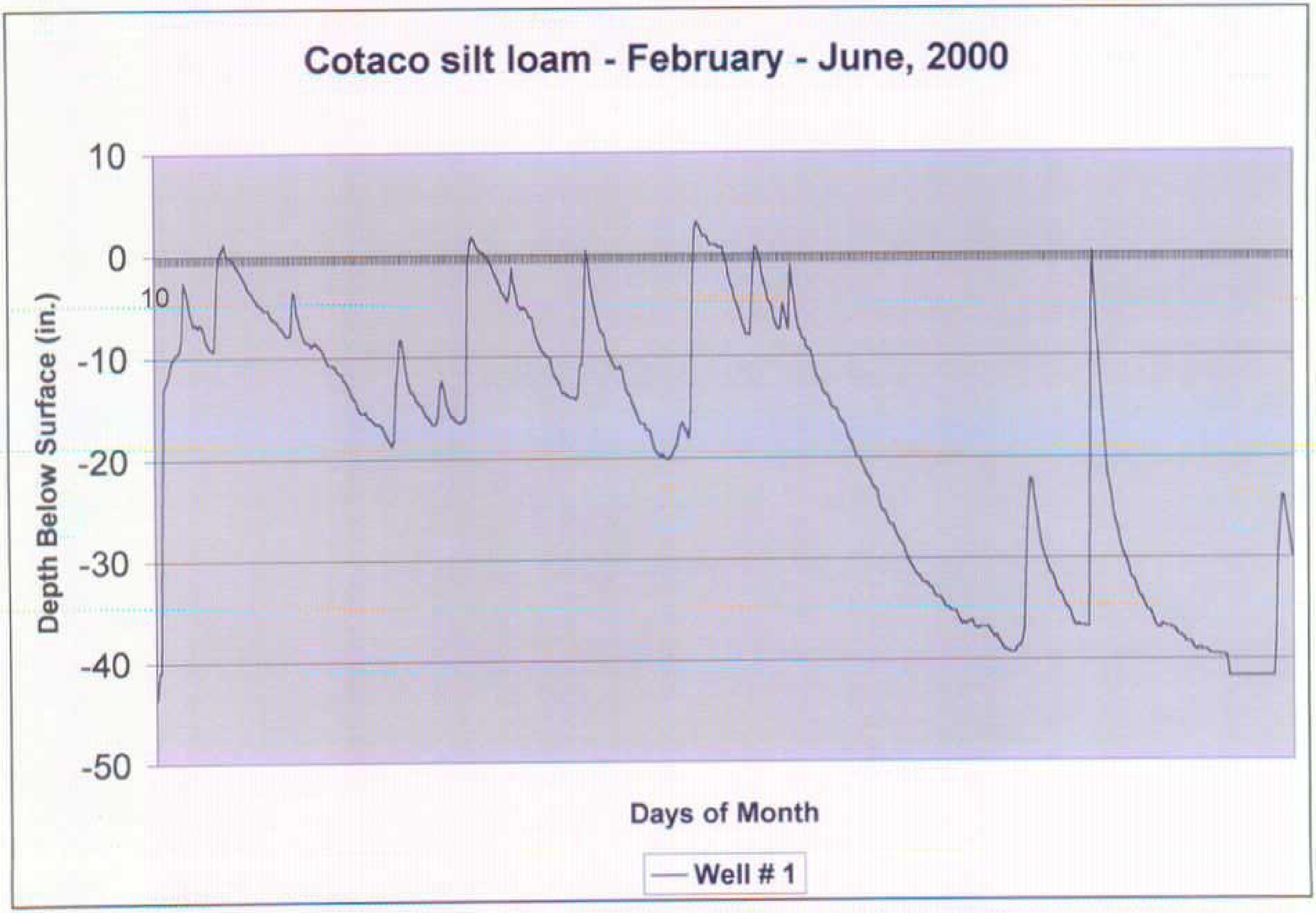
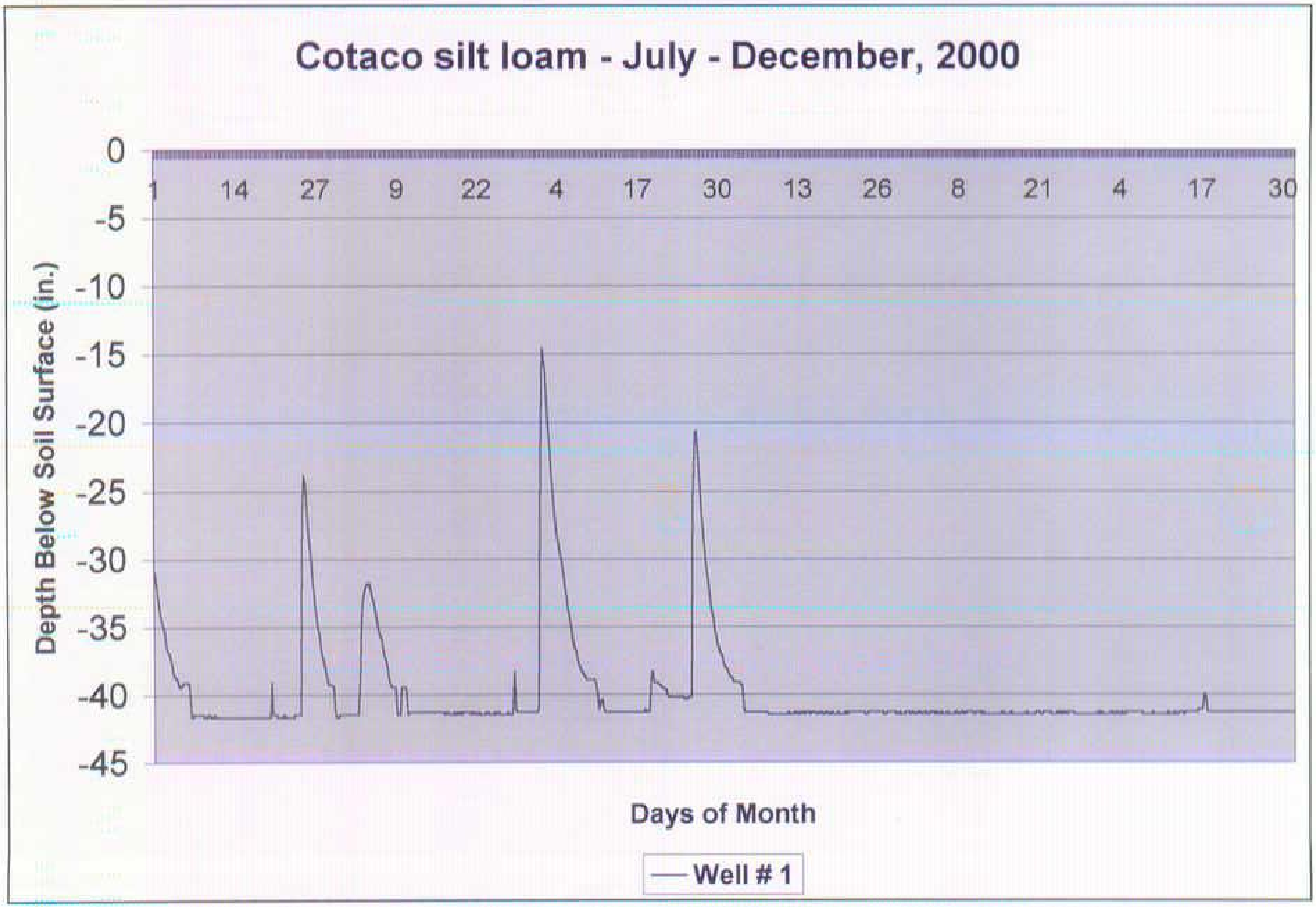
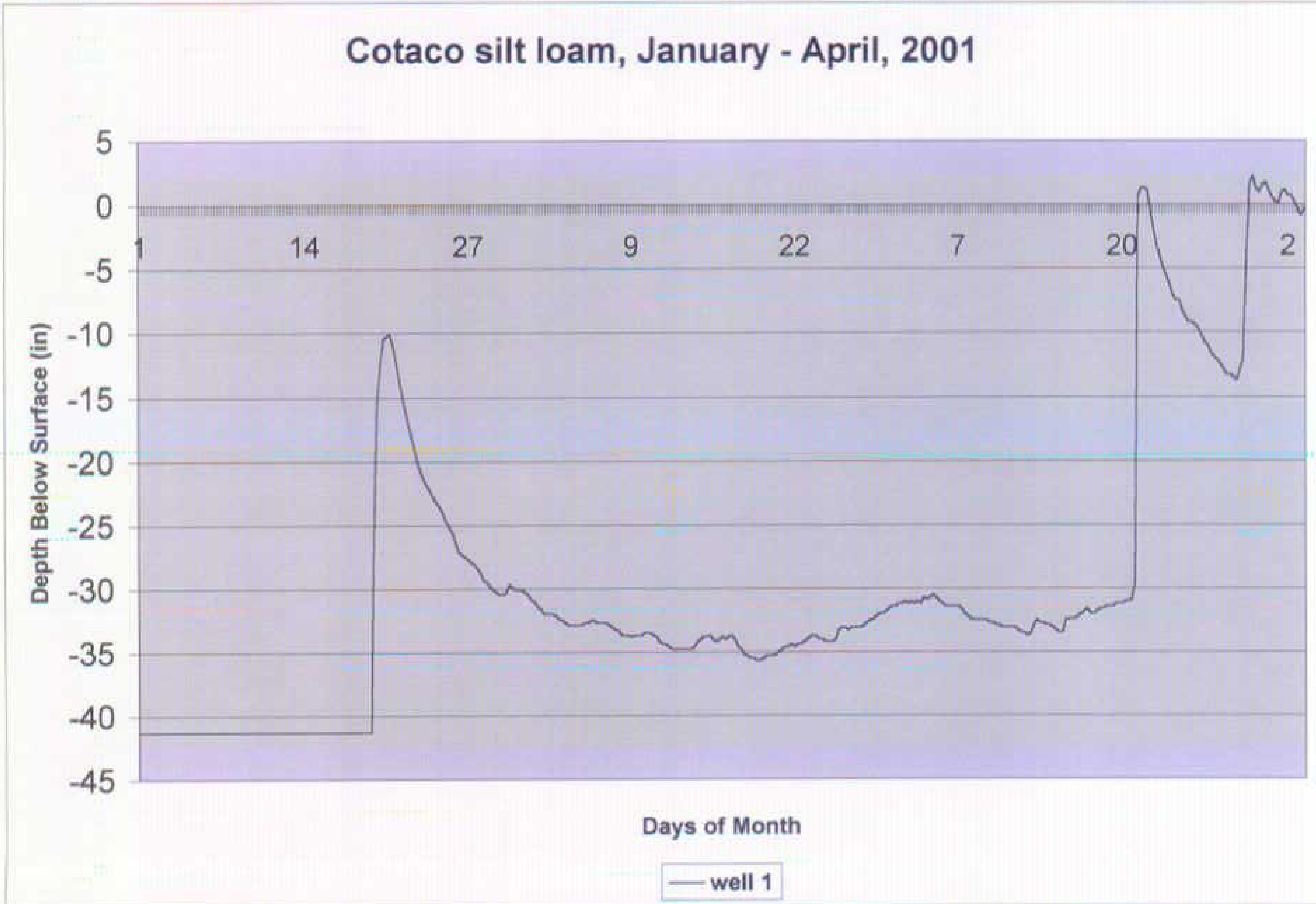

Roanoke County Precipitation
Precipitation in)
0
1
2
3
4
5
6
7
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
29 Year Average
1999
2000


Cotaco silt loam - February - June, 2000
10
0
10
-10
-20
-30
-40
-50
Depth Below Surface (in.)
Days of Month
Well # 1


Cotaco silt loam - July - December, 2000
Depth Below Soil Surface (in.)
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
1
14
27
9
22
4
17
30
13
26
8
21
4
17
30
Days of Month
Well # 1


Cotaco silt loam, January - April, 2001
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
Depth Below Surface (in)
1
14
27
9
22
7
20
2
Days of Month
well 1

SOIL EVALUATED: Dogue fine sandy loam

LOCATION:

This research site was located in the central portion of the City of Suffolk, Virginia. Refer to the accompanying portion of the Buckhorn U.S. Geologic Survey topographic map for the general character of the area. The accompanying detailed site sketch shows the location of two automated WL-40 data loggers on this residential property.

RATIONALE FOR SITE SELECTION:

There were several reasons for using this site. First, the type of soil at the site, Dogue, represents a major soil type located over large areas in the state. To study it would provide valuable information that could apply to numerous sites considered for onsite septic systems. Second, while the Dogue soil meets Virginia criteria to allow installation of an alternative type system, it is unsuitable for a conventional gravity drainfield because this soil type often does not work properly on a year-round basis. And finally, the residence at this site employs an alternative onsite wastewater disposal system (elevated Wisconsin mound), so a water table study would provide information on how well this alternative wastewater system works in problem soils.

SOILAND-SI-'[E.INEORMAT-ION:

The soil at this site formed in very fine textured, stratified, unconsolidated, fluvio-marine sediments of the middle Coastal Plain. There was a broad, nearly level fiat adjacent to the site. The site was on the Iow ridge, very near a small drainageway. The wells were located in the yard, vegetated with fescue-type lawn grasses'.

The published Soil Survey of City of Suffolk, Virginia, Earl J. Reber, et. al., June, 1981, shows the research site as being mapped as Eunola loamy fine sand, 0 to 2 percent slopes (8A). Eunole is a moderately well drained soil. The research site has finer or more clayey textures throughout than is listed in the mapping unit. This would have been considered an inclusion in the mapping unit.

A detailed soil profile description was made at the site and is included. When compared to the official soil series description for the Eunole series (not in the Appendix), the soil at this site falls outside the range of characteristics. That means the soil was not typical or representative of Eunole soils. The soil at the research site more closely relates to Dogue fine sandy loam, 0 to 2 percent slopes (5A) (refer to the Appendix). This soil had more clay and silt in the Bt and Btg horizons than is allowed in Eunole. This soil site is more closely related to Dogue soils and is listed as an inclusion in the Eunole mapping unit.

Since the soil was unsuitable for a conventional gravity drainfield, a modified Wisconsin Mound system was permitted due to insufficient depth of suitable soils to wetness characteristics. This soil would have required a 16-inch standoff below trench bottom to wetness indicators due to texture and permeability. The depth to wetness indicators should have been 34 inches and this site had only 18 inches to chroma 2 or less mottles. The modified system has an additional 6 ' inches of height for additional treatment due to less standoff within the soil to wetness indicators.

CLIMATIC DATA FOR THE SITE:

The site was less than 4 miles from the Tidewater Agricultural Research and Extension Center at Holland, where official weather data are collected. Precipitation data from the research center was used to evaluate rainfall during the study period. The precipitation comparison graph shows how each month's rainfall total compares to the monthly 68-year average (1933-2001).

It is apparent that 1999 was a very abnormal year. Hurricanes Dennis, Floyd and Irene produced rainfall totals in excess of 31 inches during a six week period from September 3 through October 18. For the January-June period, precipitation was slightly below normal with 1.80 inches short or 92%. For the July-December period, precipitation was dramatically above normal. In fact, rainfall was 190% of the long-term average for that period. Therefore, the water table levels at the site for the. year preceding:the study would be expected to be shallower (nearer to the surface) than during a year with normal precipitation.

For the period January-June 2000, total precipitation was 3.55 inches above the 68-year average or 116%. That means that the water table levels would be expected to be slightly above normal at the site.

For the period July-September 2000, monthly rainfall was slightly below normal. Precipitation for the three months was 0.20 inches below the 68-year average or 99%. That means that the water table levels would be expected to be normal at the site.

Five of the nine months (January, April, May, June and August 2000) had precipitation levels above normal. For the entire study period of January-September of 2000, overall precipitation was 2.52 inches below the 68-year average or 93%. Water table levels would be expected to be normal at the site.

RESULTS:

Two automated data loggers well were installed on February 10, 2000. Wells were installed in the same soil, same landscape position and at the same topographic elevation. Well # I was installed in the footprint of the elevated

Wisconsin mound and Well # 2 was installed about 220 feet away. Well # 2 was representative of the soil conditions at the Wisconsin mound site but was remote enough to be unaffected by the wastewater system. There was continuous data collection from the starting date until September 8, 2000 for Well # 2 and June 15, 2000 for Well # 1. Well # 1 was broken by the homeowner mowing grass.

The Dogue soil at this site had common light gray (10YR 7/1) mottles (or iron depletions) below 18 inches in the Bt2 horizon, making it a moderately well drained soil. Normally, it would be assumed that the seasonal water table would be below 18 inches, while there might be brief periods where it was above that depth. These soils normally have a perched water table. Yellowish red (5YR 5/6) and pale brown (10YR 6/3) mottles were found in the top of the Bt horizon at 12 inches. The Bt2 and Bt3 horizons were restrictive. The mottling at shallower depths in the Bt1 and Bt2 hodzons was suspected, to be associated with the fluctuating seasonal water table.

The water table hydrograph of February -. June, 2000 shows the presence of free waterin the soil within 12 inches for 35-49 days, 12-18 inches for 69-71 days, 18-24 inches for 89-100 days, 24-30 inches for 107-114 days, 30-36 inches for 117-130 days, 36-40 inches for 124-139 days and dry for.2 days. Well # 1 had free water closer to the surface for a longer period of time due to contributions to groundwater from the wastewater system. Precipitation was above normal during this period being 116 percent of normal. This wetness was observed above the chroma 2 or less mottles. The water levels dropped after April 1 due to shrubs and trees leafing-out and a rapid increase in the evapotranspiration at the site except during precipitation events.

The February - June, 2000 Groundwater Data Table shows that the surface of the free water for Well # I was in the Ap horizon 49 days or '39% 'of the time during this 126 day period, in the Bt1 horizon 71 days or 56% of the time, in the Bt2 horizon 98-117 days or 78-93% of the time and the Bt3 horizon 124 days or 98% of the time. The Btg horizon was dry for 2 days or 2% of the time. For Well # 2, the surface of the free water was in the Ap horizon 35 days or 25% of the time during this 141 day period, in the Bt1 horizon 69 days or 49% of the time, in the Bt2 horizon 100 days or 71% of the time and the Btg horizon 114-139 days or 81-99% of the time. The lower Btg hodzon was dry for 2 days or 2% of the time.

The water table hydrograph of July - September, 2000 shows the presence of free water in the soil within 12 inches for 17 days, 12-18 inches for 29 days, 18-24 inches for 39 days, 24-30 inches for 50 days, 30-36 inches for 56 days,' 36-40 inches for 59 days and dry for 11 days. This wetness was observed above the chroma 2 or less mottles. Precipitation was 1.28 inches above normal or 122 percent of normal.

The July - September, 2000 Groundwater Data Table shows that the surface of the free water for Well # 2 was in the Ap horizon 17 days or 24% of the time during this 70 day period, in the Bt1 hodzon 29 days or 42% of the time, in the Bt2 horizon 39days or 56% of the time and the Btg horizon 50-59 days or 72-85% of the time. The lower Btg horizon was dry for 11 days or 45% of the time.

CONCLUSIONS:

This site had precipitation levels slightly above normal for 4 months of the 8 months the study was conducted. Those four months, April, May, June and August, had totals of 22.91 inches, 5.83 inches above normal. That relates to 134% of normal precipitation for the four months. The total study period (8 months) had 35.98 inches. Based on the 68-year average, this relates to 104% of normal precipitation.

In spite of near normal precipitation, free water was present for significant periods of time during the study period. In addition, the depth to free water was much shallower than where gray mottles were found in the soil. Once the water table rose in the soil, it remained for an extended period of time.

'Free water was observed in the Ap horizon for fairly long periods of time and was always associated with precipitous rises in the water table. For the entire study period, free water was in this horizon for 49 to 52 days of the total 211 days or 23 to 25 percent of the time, though not continuously. There were no soil morphological.features, that could be,. related to the presence, of water, in the soil for the number of days observed.

Free water was observed in the .Bt1 horizon for 71 to 98 days of the total 211 days during the entire study period and was always associated with sharp rises in the water table. This relates to 34 to 46 percent of the time. Yellowish red (5YR 5/6) and pale brown (10YR 6/3) mottles were soil morphological features that could be related to the presence of water in the soil for the number of days observed.

Free water was observed in the Bt2 and Bt3 horizons for 98 to 129 days of the total 211 days during the entire study period and was always associated with sharp rises in the water table. This relates to 46 to 61 percent of the time. Yellowish red (5YR 5/6) and light gray (10YR 7/1) mottles were soil morphological features that could be related to the presence of water in the soil for the number of days observed.

Free water was observed in the Btg horizon for 164 to 211 days of the total 211 days during the entire study period and was always associated with sharp rises in the water table. This relates to 78 to 100 percent of the time. Yellowish red

(5YR 5/6) and brownish yellow (10YR 6/6) mottles in a gleyed matrix were soil morphological features that could be related to the presence of water in the soil for extended periods of time.

The presence of yellowish red (5YR 5/6) and pale brown (10YR 6/3) redoximorphic features (mottles) were soil morphologic features that could be related to the presence of water in the soil for extended periods of time. During the winter-spring time of the year, the seasonal water table was present in the Bt1 horizon for 1/3 to 1/2 of the time. The presence of restrictive hodzons deeper in the profile contributes to the longevity of the seasonal saturation.

It must be remembered that when the surface of the water table was in one of the upper horizons such as the Bt1, the Bt2 and lower horizons were saturated. Free water was observed in the Bt2 and Bt3 horizons for 1/2 to 3/5 of the time. These horizons had yellowish red (5YR 5/6) and light gray (10YR 7/1) redoximorphic features (mottles).

Redoximorphic features (mottles) in the Btg horizon were exhibited as yellowish red (5YR 5/6) and brownish yellow (10YR 6/6) mottles in a gleyed matrix. Since this was the lowest horizon in the profile and gleyed, the seasonal water table would be expected to have a longer duration than the upper horizons.

As was noted earlier, this soil exceeded the minimum state requirements for a conventional gravity drainfield based on soil morphology. Based on the period studied, it is apparent that if a conventional septic system had been installed, the gravel filled trenches (at a depth of 18 inches) would have been inundated with free water for extended periods of time. Based on the state sewage regulations in effect when the permit was issued, a 16 inch zone of suitable soil beneath the gravel filled trenches would have been required (the "stand-off zone") for treatment and disposal of the wastewater. Based on this research, the seasonal water table would have been in the "stand-off zone" at least 49% to 93% of the time during a winter-spring period. Although soil morphology indicated this soil was unsuitable for a conventional gravity drainfield, the monitoring data taken while there was slightly above normal precipitation showed the soil was unsuitable.

An elevated Wisconsin mound 'system was installed at this site and it required a "stand-off zone" of 18 inches beneath the surface. Based on this installation depth, the seasonal water table would have periodically risen into the "stand-off zone". Based on this research, the seasonal water table would have been in the "stand-off zone" at least 49% to 56% of the time during a winter-spring period.

Dogue fine sandy loam

Profile for Well # 1: (WL40)

Ap--0 to 12 inches, brown (10YR 5/3) sandy loam; many fine and medium prominent yellowish red (5YR 5/6) mottles; weak coarse granular structure parting to single grain; very friable, nonsticky, nonplastic.

Btl--12 to 18 inches, brownish yellow (10YR 6/6) sandy clay loam; common medium distinct yellowish red (5YR 5/6) and pale brown (10YR 6/3) mottles; weak medium subangular blocky structure; friable, slightly sticky, slightly plastic.

Bt2--18 to 36 inches, brownish yellow (10YR 6/6) clay loam; common medium and coarse prominent yellowish red (5YR 5/6) and light gray (10YR 7/1) mottles; moderate medium subangular blocky structure; friable, sticky, slightly plastic.

Bt3--36 to 42 inches, mottled brownish yellow (10YR 6/6), .yellowish red (5YR 5/6)'and light gray (10YR 7/1) clay loam; moderate medium subangular blocky structure parting to weak medium platy strUcture; firm, sticky, plastic.

Btg--42 to 48 inches, light gray (10YR 7/1) clay loam; many medium and coarse prominent brownish yellow (10YR 6/6) and yellowish red (5YR 5/6) mottles; massive; firm in place; firm, sticky, plastic.

Remarks: This profile taken from an auger hole.

Profile for Well # 2: (WL40)

Ap--0 to 12 inches, dark grayish brown (10YR 4/2) .fine sandy loam; weak coarse granular structure; friable, nonsticky, nonplastic.

Btl--12 to 18 inches, brownish yellow (10YR 6/6) sandy clay loam; many medium distinct yellowish red (5YR 5/6) and pale brown (10YR 6/3) mottles; weak medium subangular blocky structure; friable, slightly sticky, slightly plastic.

Bt2--18 to 24 inches, mottled brownish yellow (10YR 6/6), yellowish red (5YR 5/6) and light gray (10YR 7/1) clay loam; moderate medium subangular blocky structure; firm, slightly sticky, slightly plastic.

Btg--24 to 48 inches, light gray (10YR 7/1) clay loam; many medium and coarse prominent brownish yellow (10YR 6/6) and yellowish red (5YR 5/6) mottles; massive; firm in place; firm, sticky, plastic.

Remarks: This profile taken from an auger hole.

Table I - - Dogue fine sandy loam Groundwater Data Table
January-June, 2000 (141 Days)

	Well # 1				Well # 2			
Depth Range (in.)	Number of Days	Percent Time	Percent Cumulative Days	Cumulative Days	Number of Days	perCent Time	Percent Cumulative Days	Cumulative Days
0- 6	22	17	22	17	6	4	6	4
6.1-12	27	21	49	39	29	21	35	25
12.1-18	22	17	71	56	34	24	69	49
18.1-24	27	21	98	78	31	22	100	71
24.1-30	9	7	107	85	14	10	114	81
30.1-36	10	9	117	93	16	11	130	92
36.1-40	7	6	124	98	9	6	139	99
Dry	2	2	126	100	2	2	141	100

Table 2 - - Dogue fine sandy loam Groundwater Data Table
July-September, 2000 (70 Days)

	Well # 1				Well # 2			
Depth Range (in.)	Number of Days	Percent Time	Percent Cumulative Days	Cumulative Days	Number of Days	Percent Time	Percent Cumulative Days	Cumulative Days
0-6					5	7	5	7
· 6.1-12					12	17	17	24
12.1-18					12	17	29	42
18.1-24					10	15	39	56
24.1-30					11	16	50	72
30.1-36					6	8	56	80
36.1-40					3	5	59	85
Dry					11	15	70	100

Number of Days column refers to the number of days the surface of the free water was present within the depth range.

Percentage of Time column refers to the percent of time the water was present within the depth range.

Cumulative Days column refers to the total number of days the water was present within the depth range.

Percentage of Cumulative Days refers to the percent of total time the water was present within the depth range.

DRY corresponds to the' number of readings (converted to days) where the monitoring well recorded no water in the hole.

Days in the column headings corresponds to the number of data logger readings within a depth range divided by the number (normally 2, 4 or 8) of data logger readings per day.

City of Suffolk

Dogue Fine Sandy Loam

LUmmis Road Scale: 1": 50'

/

,

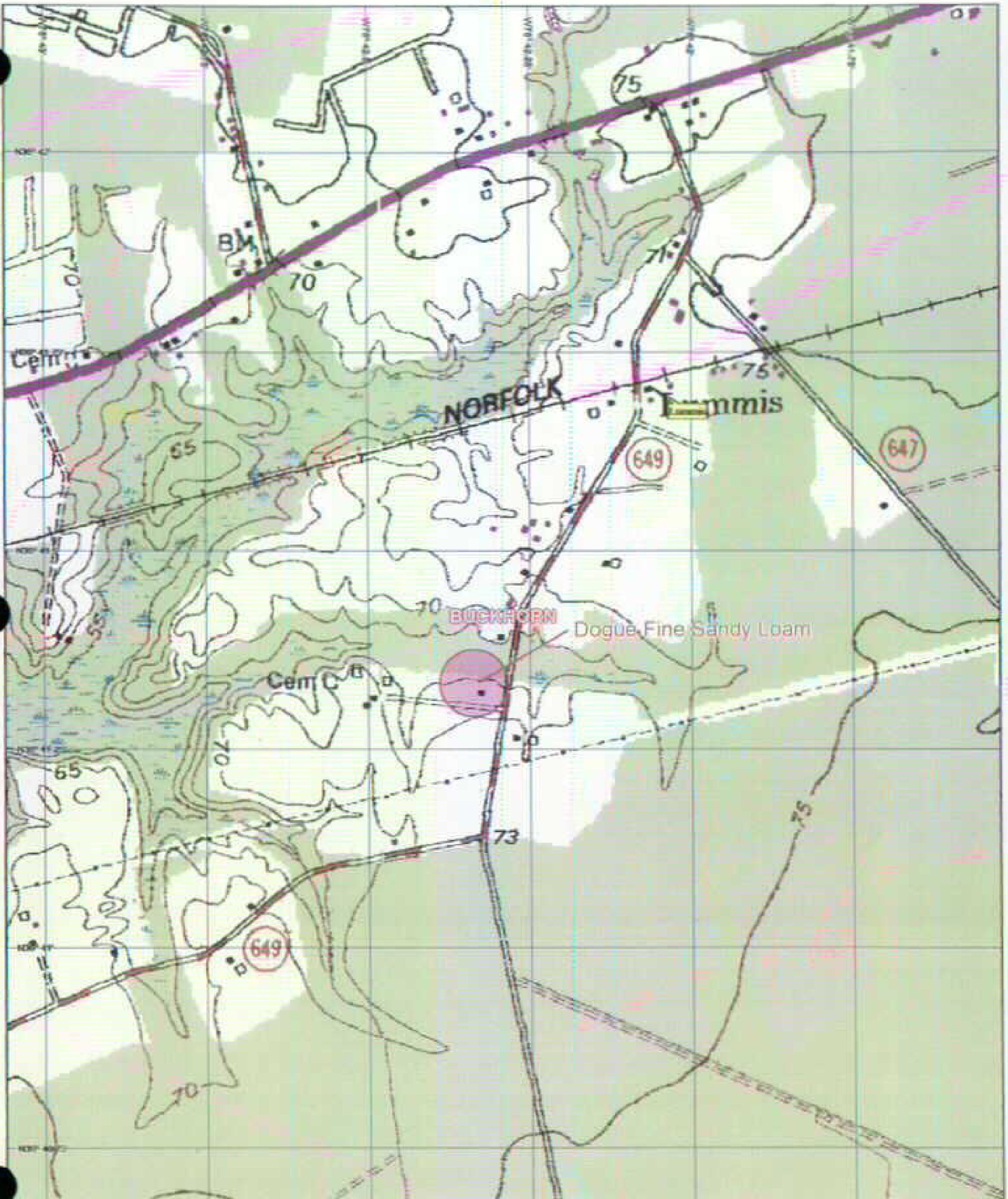
Data ko§§er #2

~ House garage

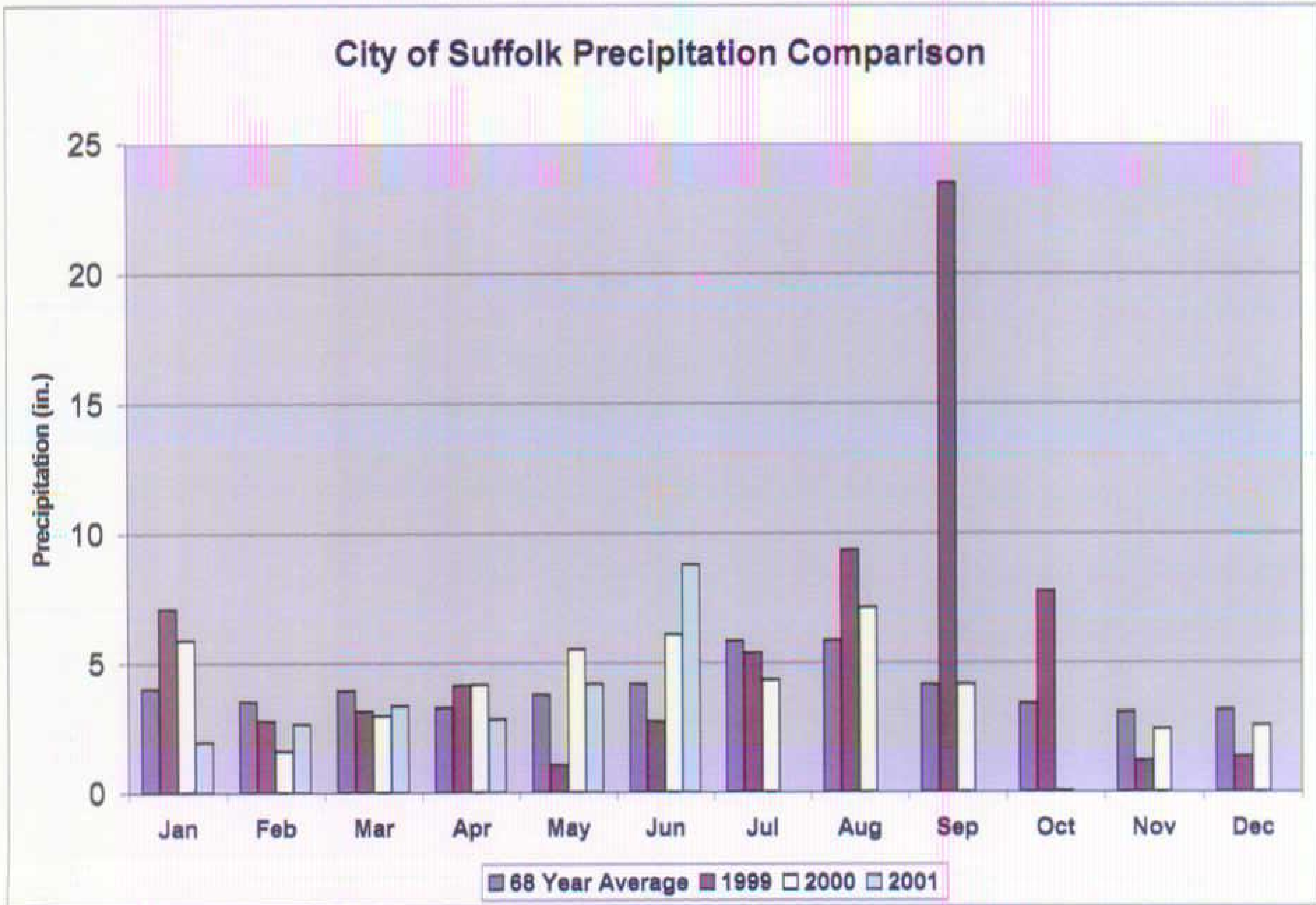
/ 170'

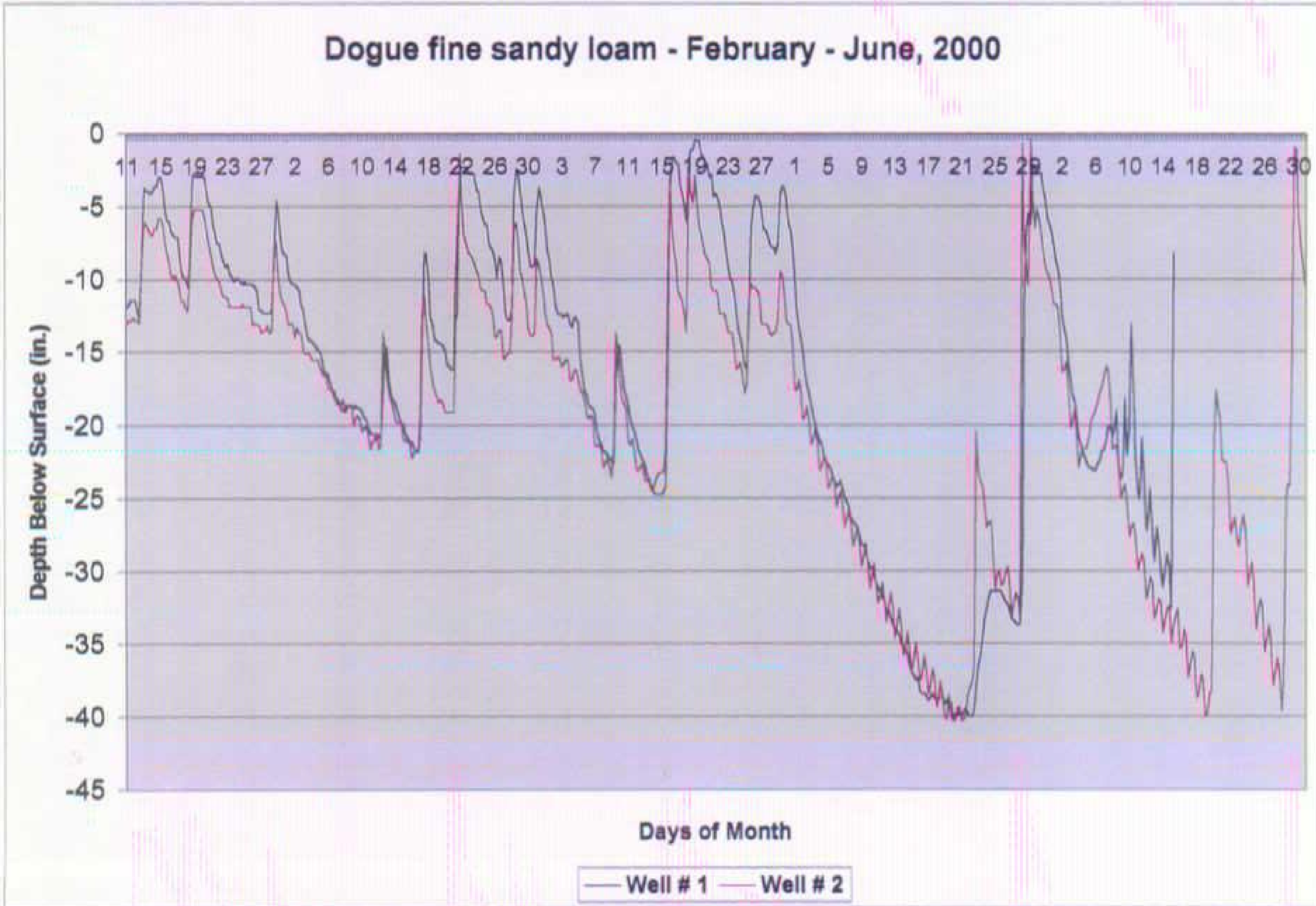
Mound

Data Logger #1 WL-.40

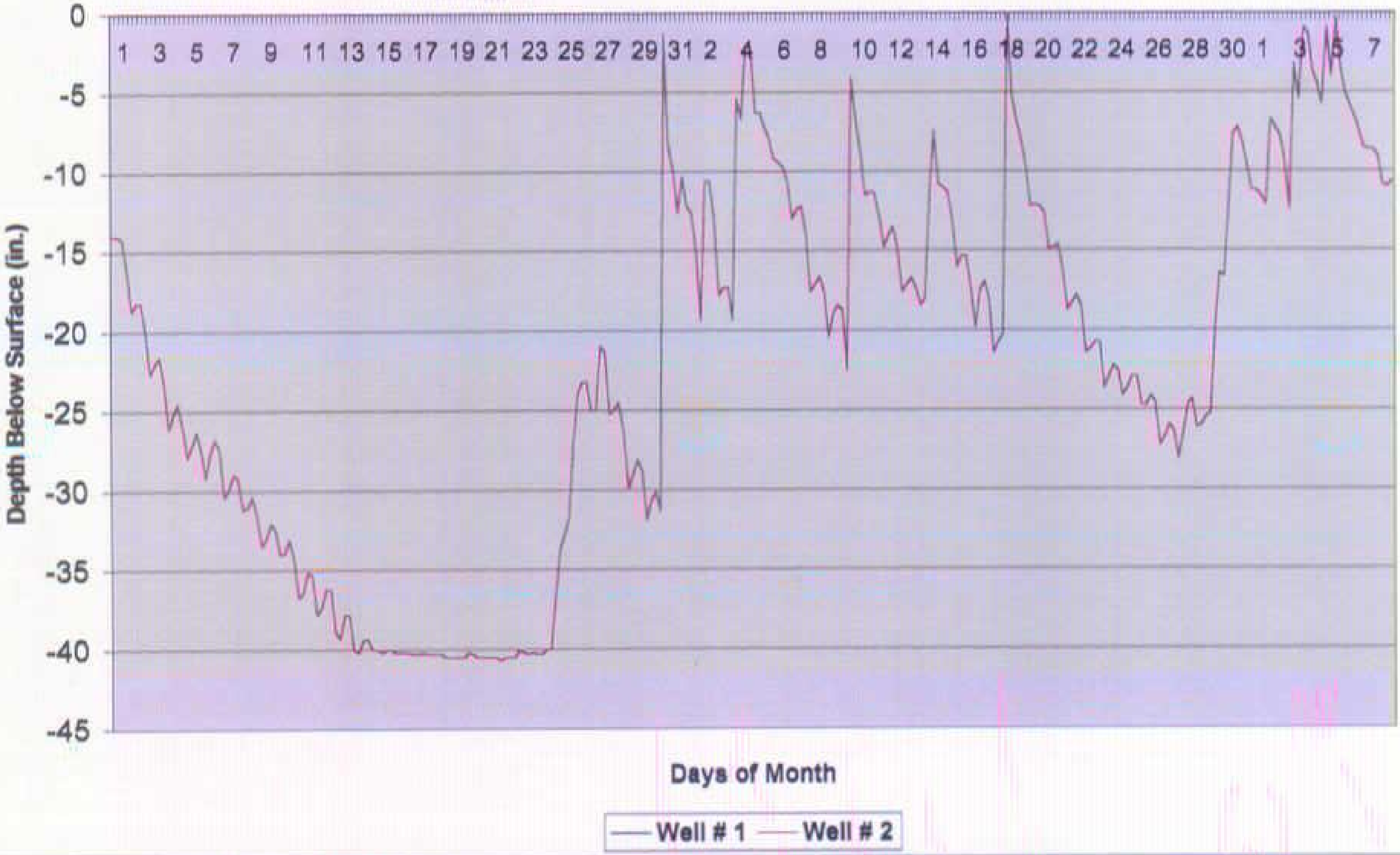


 450 ft Scale: 1 : 12,000 Detail: 14-2 Datum: WGS84


City of Suffolk Precipitation Comparison
Precipitation (in.)
25
20
15
10
5
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
68 Year Average
1999
2000
2001


Dogue fine sandy loam - February - June, 2000
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
Depth Below Surface (in.)
11 15 19 23 27 2 6 10 14 18 22 26 30 3 7 11 15 19 23 27 1 5 9 13 17 21 25 29 2 6 10 14 18 22 26 30
Days of Month
Well # 1
Well # 2

Dogue fine sandy loam - July - September, 2000



SOIL EVALUATED: Dragston fine sandy loam

LOCATION:

This research site was located in the central portion of Northampton County, Virginia. Refer to the accompanying portion of the Nassawadox U.S. Geologic Survey topographic map for the general character of the area. The accompanying detailed site sketch shows the location of two automated WL-40 data loggers on this residential/commercial property. This property provides single family housing for Iow income residents.

RATIONALE FOR SITE SELECTION:

There were several reasons for using this site. First, the type of soil at the site, Dragston, represents a major soil type located over large areas in the state. To study it would provide valuable information that could apply to numerous sites considered for onsite septic systems. Second, while the Dragston soil does not meet Virginia criteria to allow installation of a conventional gravity drainfield, alternative wastewater systems requiring less standoff to limitations are available. And finally, the residence at this site employs an alternative onsite wastewater disposal system, so a water table study woUld provide information on how well this alternative septic system works in problem soils.

SOILAND_SlTEINEORMATION:

The soil at this site formed in mOderately coarse textured, stratified, unconsolidated, fiuvio-marine sediments of the lower and middle Coastal Plain. The site was in the Iow depression with slightly higher uplands nearby. The wells were located in a small wooded area and small clearing, with Well # I located in the footprint of the Puraflo pad and Well # 2 located 70 feet away in a mixed hardwood area.

'The published Soil Survey of Northampton County, Vir.qinia, Phillip R. Cobb, et.al., August 1989, shows the research site as being mapped as Dragston fine sandy loam, 0 to 2 percent slopes (DrA). Dragston is a somewhat poorly drained soil.

A detailed soil profile description was made at the site and is included. When compared to the official soil series description for the Dragston series (refer to the Appendix), the soil at this site falls within the range of characteristics. That means the soil was typical or representative of Dragston soils..

Since the soil was unsuitable for a conventional gravity drainfield, a Puraflo (peat moss) Biofilter system was permitted due to its reduced area requirements, less standoff requirements to seasonal wetness and experimental status. The 6 inches of %-1 inch diameter clean gravel was installed at grade, the modules set on the gravel pad, pipes connected and then soil backfill material used to level and landscape the site.

CLIMATIC DATA FOR THE SITE:

The site was approximately 9 miles from the Eastern Shore Agricultural Research and Extension Center at Painter, where official weather data are collected. Precipitation data from the research center was used to evaluate rainfall during the study period. The precipitation comparison graph shows how each month's rainfall total compares 'to the monthly 59-year average (1942-2001).

It is apparent that 1999 was an abnormal year. Hurricanes Dennis, Floyd and Irene produced rainfall totals in excess of 14 inches during a six week period from September 3 through October 18. For the January-June period, precipitation was normal with 20.98 inches. For the July-December period, precipitation was above normal. In fact, rainfall was 5.24 inches above normal or 124% of the long-term average for that period. Therefore, the water table levels would be expected to be above normal at the site.

For the period January-June 2000, total precipitation was 0.13 inches below the 59;year average or 99%. That means that the water table levels would be expected to be normal at the site.

For the period July-December 2000, total precipitation was 2.28 inches above the 59-year average or 110%. That means that the water table levels would be expected to be slightly above normal at the site.

For the period January-June 2001, total precipitation was 0.63 inches below the 59-year average or 97%. That means that the water table levels would be expected to be normal at the site.

Sixteen of the thirty months (January, March, June, August, September, October 1999, January, April, May, June, July, August, September 2000 and March, May and June 2001) had precipitation levels above normal. For the entire study period of January 1999 through June 2001, overall precipitation was 6.86 inches above the 59-year average or 106%. Water table levels would be expected to be slightly above normal at the site.

RESULTS:

Two automated data loggers were installed at the site on February 12,1999.

Wells were installed in the same soil, same landscape position and at the same topographic elevation. Well # 1 was' installed within the footprint of an operating Purafio wastewater system and Well # 2 was installed 66 feet away. Well # 2 was representative of the soil conditions at the Puraflo (peat moss) Biofilter system site but was remote enough to be unaffected by the wastewater system. Due to operator error, Well # 2 was not programmed properly and the collection of water table data did not commence until March 14,1999. There was continuous data collection from the starting date until July 14, 2000 for Well # 1 and December 6, 2000 for Well # 2. Well # I was vandalized and did not function after July 14, 2000.

The Dragston soil at this site had a mottled matrix of pale brown (10YR 6/3), light brownish gray (10YR 6/2) (or iron depletions) and strong brown (7.5YR 5/6) in the top of the Bt hodzon at 12 inches, making it a somewhat poorly drained soil. Btg horizons start at 30 inches with a Cg horizon at 42 inches. These soils normally have an apparent water table, which comes up from the bottom during precipitation events and goes down during dry pedods.

The water table hydrograph of February- June, 1999 shows the presence of free water in the soil within 12 inches for 13-15 days,' 12-18 inches for 26-28 days, 18-24 inches for 34-38 days, 24-30 inches for 40-56 days, 30-36 inches for 51-70 days, 36-40 inches for 72-82 days and dry for 22-48 days. Rainfall for this period was average or 20.98 inches. March and June were above normal in precipitation but April and May were below normal.

The February - June, 1999 Groundwater Data Table shows that the surface of the free water for Well # 1 was in the Ap and E horizons 15 days or 12% of the time dur~ing~this__13_1~, day.period,,_in~.the~_Bt_horizon.28-.56 days. or 21-43% of the.- time and the Btg horizons 70-82 days or 54-63% of the time. The Cg horizon was dry for 48 days or 37% of the time. For Well # 2, the surface of the free water was in the Ap and E horizons 13 days or 14% of the time during this 94 day period, in the Bt horizon 26-40 days or 28-42% of the time and the Btg hodzons 51-72 days or 55-76% of the time. The Cg horizon was dry for 22 days or 23% of the time.

The water table hydrograph of July - December, 1999 shows the presence of free water in the soil within 12 inches for 9 days, 12-18 inches for 12-13 days, 18-24 inches for 22-23 days, 24-30 inches for 37-39 days, 30-36 inches for 60-69 days, 36-40 inches for 85-139 days and dry for 45-99 days. Rainfall for this period was above average or 27.06 inches. Precipitation during the six week period of the hurricanes was 15.26 inches but only 5.24 inches above normal for the entire six month period. Most of the remainder of the time was well below normal rainfall.

The July - December, 1999 Groundwater Data Table shows that the surface of · the free water for Well # 1 was in the Ap and E horizons 9 days or 5% of the time during this 184 day period, in the Bt horizon 13-37 days or 7-20% of the time and the Btg horizons 60-85 days or 33-46% of the time. The Cg horizon was dry for 99 days or 53% of the time. For Well # 2, the surface of the free water was in the Ap and E horizons 9 days or 5% of the time, in the Bt horizon 12-39 days or 7-

21% of the time and the Btg horizons 69-139 days or 38-75% of. the time. The Cg horizon was dry for 45 days or 25% of the time.

The water table hydrograph of January - June, 2000 shows the presence of free water in the soil within 12 inches for 20 days, 12-18 inches for 38-40 days, 18-24 inches for 73-74 days, 24-30 inches for 111-119 days, 30-36 inches for 158-163 days, 36-40 inches for 180-182 days and dry for 0-2 days. Rainfall for this period was slightly below average or 20.85 inches.

The January - June, 2000 Groundwater Data Table shows that the surface of the free water for Well # 1 was in the Ap and E' horizons 20 days or 11% of the time during this 182 day period, in the Bt horizon 40-111 days or 21-61% of the time and the Btg horizons 158-180 days or 87-99% of the time. The Cg horizon was dry for 2 days or 2% of the time. For Well # 2, the surface of the free water was in the Ap and E horizons 20 days or 11% of the time, in the Bt horizon 38-119 days or 21-65% of the time and the Btg horizons 163-182 days or 89-100% of the time. The Cg horizon was not dry for this monitoring period.

The water table hydrograph of July - December, 2000 shows the presence of free water in the soil within 12 inches for 0 days, 12-18 inches for 0-2 days, 18-24 inches for 0-10 days, 24-30 inches for 0-31 days, 30-36 inches for 0-60 days, 36-40 inches for 8-159 days and dry for 0-6 days. Rainfall for this period was slightly above average or 24.10 inches.

The July - December, 2000 Groundwater Data Table shows that the surface of the free water for Well # 1 was never in the Ap, E, Bt nor Btg 1 horizons during this 14 day period but was in the Btg2 horizon 8 days or 57% of the time. The Cg horizon was dry for 6 days or 43% of the time. For Well # 2, the surface of the free water was never in the Ap nor E horizons during the 159 day period but was in the Bt horizon 2-31 days or 1-19% of the time and the Btg horizons 60-159 days or 38-100% of the time. The Cg horizon was not dry for this monitoring period.

CONCLUSIONS:

This site had precipitation levels dramatically above normal for 12 months of the 23 months the study was conducted. Those twelve months, March, June, August, September and October, 1999; January, April, May, June, July, August and September, 2000; had totals of 67.45 inches, 23.54 inches above normal. That relates to 154% of normal precipitation for the twelve months. The total study period (23 months) had 88.76 inches. Based on the 59-year average, this relates to 113% of normal precipitation.

In spite of near normal precipitation, free water was present for significant periods of time during the study period. In addition, the depth to free water was much shallower than where gray mottles were found in the soil. Once the table rose in the soil, it remained for an extended period of time.

Free water was observed in the Ap and E horizons for fairly long periods of time and was always associated with precipitous dses in the water table. For the entire study period, free water was in these horizons for 42 to 44 days of the total 656 days or 6 to 9 percent of the time, though not continuously. There were no soil morphological features that could be related to the presence of water in the soil for the number of days observed.

Free water was observed in the Bt horizon for 63 to 229 days of the total 656 days during the entire study period and was always associated with sharp rises in the water table. This relates to 10 to 40 percent of the time. Pale brown (10YR 6~3), light brownish gray (10YR 6~2) and strong brown (7.5YR 5~6) mottles were soil morphological features that could be related to the presence of water in the soil for the number of days observed.

Free water was observed in the Btgl horizon for 288 to 343 days of the total 656 days during the entire study period and was always associated with sharp rises in the water table. This relates to 52 to 56 percent of the time. Strong brown (7.5YR 5~6) and pale brown (10YR 6~3) mottles in a gleyed matrix horizon were soil morphological features that could be related to the presence of water in the soil for the number of days observed.

Free water was observed in the Btg2 horizon for 355 to 552 days of the total 656 days during the entire study period and was always associated with sharp rises in the water table. This relates to 69 to 84 percent of the time. Strong brown (7.5YR 5~6) and pale brown (10YR 6~3) mottles in a gleyed matrix horizon were soil morphological features that could be related to the presence of water in the soil for the number of days observed.

The presence of pale brown (10YR 6/3), light brownish gray (10YR 6/2) and strong brown (7.5YR 5/6) redoximorphic features (mottles) were soil morphologic features that could be related to the presence of water in the soil for extended periods of time. During the winter-spring time of the year, the seasonal water table was present in the Bt horizon for 1/5 to 6/10 of the time.

It must be remembered that when the surface of the water table was in one of the upper horizons such as the Bt, the Btgl and lower horizons were saturated. Free water was observed in the Btgl horizon for 3/4 to 8/10 of the time and 8/10 to 9/10 of the time in the Btg2 horizon. These horizons had strong brown (7.5YR 5/6) and pale brown (10YR 6/3) redoximorphic features (mottles) in a gleyed matrix.

Redoximorphic features (mottles) in the Cg horizon were exhibited as strong brown (7.5YR 5/6) and pale brown (10YR 6/3) mottles in a gleyed matrix. Since this was the lowest horizon in the profile and gleyed, the seasonal water table would be expected to have a longer duration than the upper horizons.

As was noted earlier, this soil exceeded the minimum state requirements for a conventional gravity drainfield based on soil morphology. Based on the pedod studied, it is apparent that if a conventional septic system had been installed, the gravel filled trenches (at a depth of 18 inches) would have been inundated with free water for extended periods of time. Based on the state sewage regulations in effect when the application was submitted, a 6-inch zone of suitable soil beneath the gravel filled trenches would have been required (the "stand-off zone") for treatment and disposal of the wastewater. Based on this research, the seasonal water table would have been in the "stand-off zone" at least 35% to 39% of the time during a winter-spring period. Although soil morphology indicated this soil was unsuitable for a conventional gravity drainfield, the monitoring data taken while there was above normal precipitation showed the soil was unsuitable.

Since the soil was unsuitable for a conventional gravity drainfield, a Puraflo (peat moss) Biofilter system had been installed at the site. Based on the state sewage regulations in effect when the permit was issued, a 12-inch zone of suitable soil beneath the soil surface would have been required (the "stand-off zone") for treatment and disposal of the wastewater. Based on this research, the seasonal water table would have been in the "stand-off zone" at least 12% of the time during a winter-spring period.

Dragston fine sandy loam

Profile' for Well # 1: (WL40)

Ap--0 to 9 inches, mottled white (10YR 8/2) and dark grayish brown (10YR 4~2) loamy sand; single grained; loose, nonsticky, nonplastic.

E--9 to 12 inches, light yellowish brown (10YR 6/3) fine sandy loam; massive; friable, nonsticky, nonplastic.

Bt--12 to 30 inches, mottled pale brown (10YR 6/3), light brownish gray (10YR 6/2) and strong brown (7.5YR 5/6) loam; weak medium subangular blocky structure; friable, slightly sticky, slightly plastic.

Btgl-30 to 36 inches, light brownish gray (10YR 6/2) loam; many medium and coarse distinct strong brown (7.5YR 5~6) and pale brown (10YR 6/3) mottles; weak medium subangular blocky structure; friable, slightly sticky, slightly plastic.

Btg2--36 to 42 inches, light brownish gray (10YR 6/2) sandy loam; many medium and coarse distinct strong brown (7.5YR 5/6) and pale brown (10YR 6/3) mottles; weak coarse subangular blocky structure; friable, slightly sticky, nonplastic.

Cg--42 to 48 inches, light brownish gray (10YR 6/2) loamy sand; many medium and coarse distinct strong brown (7.5YR 5/6) and pale brown (10YR 6/3) mottles; single grained; loose, nonsticky, nonplastic.

Remarks: This profile taken from an auger hole. Ap horizon thicker due to fills operations during construction of Puraflo wastewater treatment system.

Profile for Well # 2: (WL40)

Ap--0 to 6 inches, dark grayish brown (10YR 4/2) fine sandy loam; weak medium granular structure; friable, slightly sticky, nonplastic.

E--6 to 12 inches, light yellowish brown (10YR 6/3) fine sandy loam; massive; friable, nonsticky, nonplastic.

Bt--12 to 30 inches, mottled pale brown (10YR 6/3), light brownish gray (10YR 6/2) and strong brown (7.5YR 5/6) loam; weak medium subangular blocky structure; friable, slightly sticky, slightly plastic.

Btgl-30 to 36 inches, light brownish gray (10YR 6/2) loam; many medium and coarse distinct strong brown (7.5YR 5/6) and pale brown (10YR 6/3) mottles; weak medium subangular blocky structure; friable, slightly sticky, slightly plastic.

Btg2--36 to 42 inches, light brownish gray (10YR 6/2) sandy loam; many medium and coarse distinct strong brown (7.5YR 5~6) and pale brown (10YR 6/3) mottles; weak coarse subangular blocky structure; friable, slightly sticky, nonplastic.

Cg--42 to 48 inches, light brownish gray (10YR 6/2) loamy sand; many medium and coarse distinctstrong brown (7.5YR 5/6) and pale brown (10YR 6~3) mottles; single grained; loose, nonsticky, nonplastic.

Remarks: This profile taken from an auger hole.

Table 1 - - Dragston fine sandy loam Groundwater Data Table
February-June, 1999 (131 Days)

	Well # 1				Well # 2			
			Percent		Pement			
Depth i Range (in.)	Number of Days	Percent Time	Cumulative Days	Cumulative Days	Number of Days	Percent Time	Cumulative Days	Cumulative Days
0-6	4	3	4	3	4	4	4	4
6.1-12	11	8	15	12	9	10	13	14
12.1-18	13	10	28	21	13	14	26	28
18.1-24	10	8	38	29	7	8	34	36
24.1-30	18	14	56	43	6	6	40	42
30.1-36	14	10	70	54	12	12	51	55
36.1-40	13	10	82	63	20	22	72	76
Dry	48	37	131	100	22	23	94	100

Table 2 - - Dragston fine sandy loam Groundwater Data Table
July-December, 1999 (184 Days)

	Well # 1				Well # 2			
			Percent		Percent			
Depth Range (in.)	Number of Days	Percent Time	Cumulative Days	Cumulative Days	Number of Days	Percent Time	Cumulative Days	Cumulative Days
0-6	5	3	5	3	6	3	6	3
6.1-12	4	2	9	5	3	2	9	5
12.1-18	4	2	13	7	3	2	12	7
18.1-24	9	5	22	12	11	6	23	13
24.1-30	15	8	37	20	16	9	39	21
30.1-36	23	13	60	33	30	16	69	38
36.1-40	25	14	85	46	70	37	139	75
Dry	99	53	184	100	45	25	184	. 100

Number of Days column refers to the number of days the surface of the free water was present within the depth range.

Percentage of Time column refers to the percent of time the water was present within the depth range.

Cumulative Days column refers to the total number of days the water was present within the depth range.

Percentage of Cumulative Days refers to the percent of total time the water was present within the depth range.

DRY corresponds to the number of readings (converted to days) where the monitoring well recorded no water in the hole.

Days in the column headings corresponds to the number of data logger readings within a depth range divided by the number (normally 2, 4 or 8) of data logger readings per day.

Table 3 - - Dragston fine sandy loam Groundwater Data Table
January-June, 2000 (182 Days)

	Well # 1				Well # 2			
Depth Range (in.)	Number of Days	Percent Time	Percent Cumulative Days	Cumulative Days	Number of Days	Percent Time	Percent Cumulative Days	Cumulative Days
0-6	5	2	5	3	5	3	5	3
6.1-12	15	8	20	11	15	8	20	11
12.1-18	20	11	40	21	18	10	38	21
18.1-24	33	18	73	39	35	20	74	41
24.1-30	38	21	111	61	45	25	119	65
30.1-36	47	26	158	87	44	24	163	89
36.1-40	22	12	180	99	20	11	182	100
Dry	2	2	182	100	......			

Table 4 - - Dragston fine sandy loam Groundwater Data Table
July-December, 2000 (159 Days)

	Well # 1				Well # 2			
Depth Range (in.)	Number of Days	Percent Time	Percent Cumulative Days	Cumulative Days	Number of Days	Percent Time	Percent Cumulative Days	Cumulative Days
0-6	0	0	0	0	0	0	0	0
6.1-12	0	0	0	0	0	0	0	0
12.1-18	0	0	0	0	2	1	2	1
18.1-24	0	0	0	0	8	5	10	6
24.1-30	0	0	0	0	21	13	31	19
30.1-36	0	0	0	0	29	18	60	38
36.1-40	8	57	8	57	99	63	159	100
Dry	6	43	14	100	......			

Number of Days column refers to the number of days the surface of the free water was present within the depth range.

Percentage of Time column refers to the percent of time the water was present within the depth range.

Cumulative Days column refers to the total number of days the water was present within the depth range.

Percentage of Cumulative Days refers to the percent of total time the water was present within the depth range.

DRY corresponds to the number of readings (converted to days) where the monitoring well recorded no water in the hole.

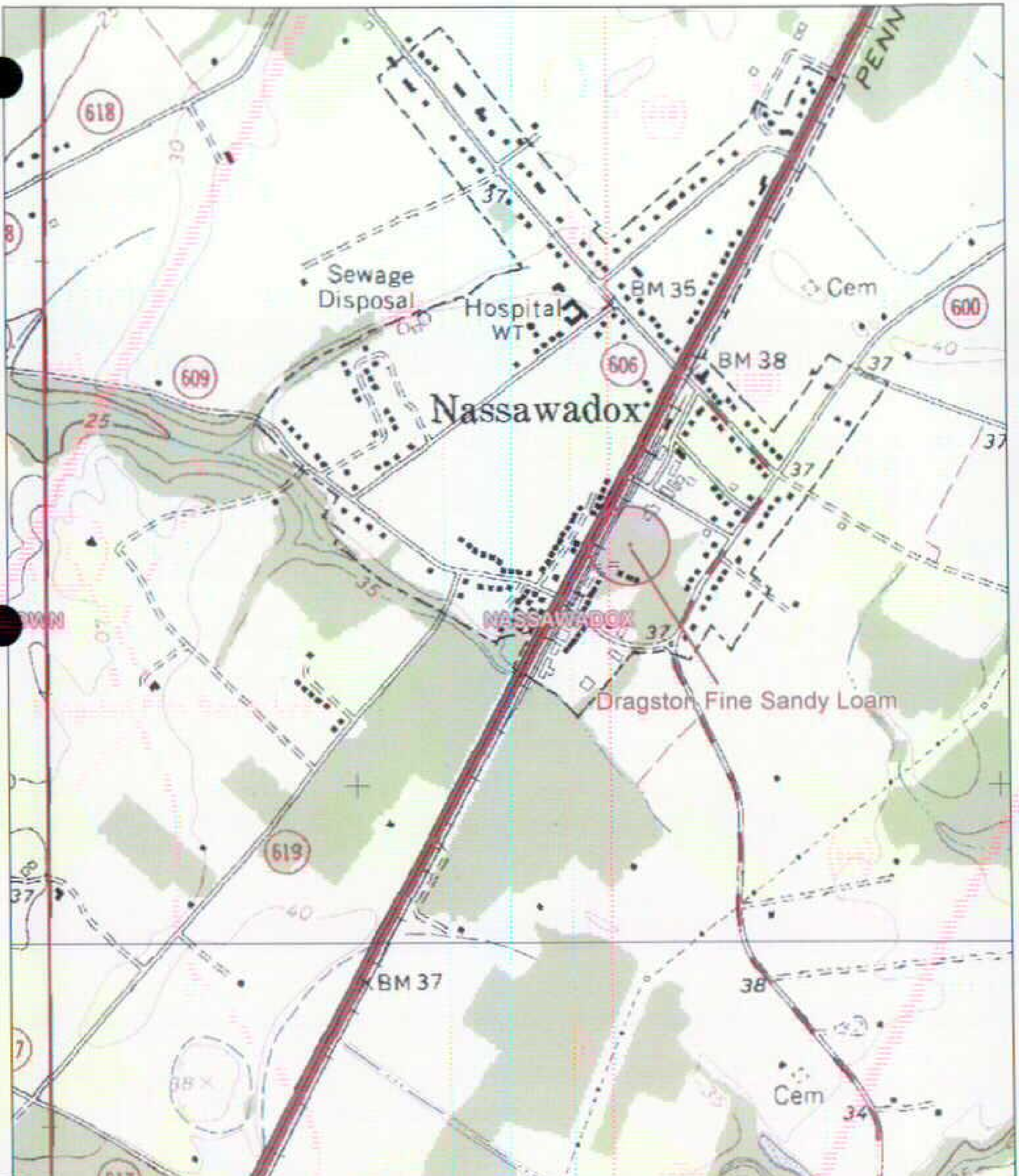
Days in the column headings corresponds to the number of data logger readings within a depth range divided by the number (normally 2, 4 or 8) of data logger readings per day.

Northampton County
Dragston Fine Sandy Loam
Scale: 1"= 30'
~ Data Logger #2
WL-40

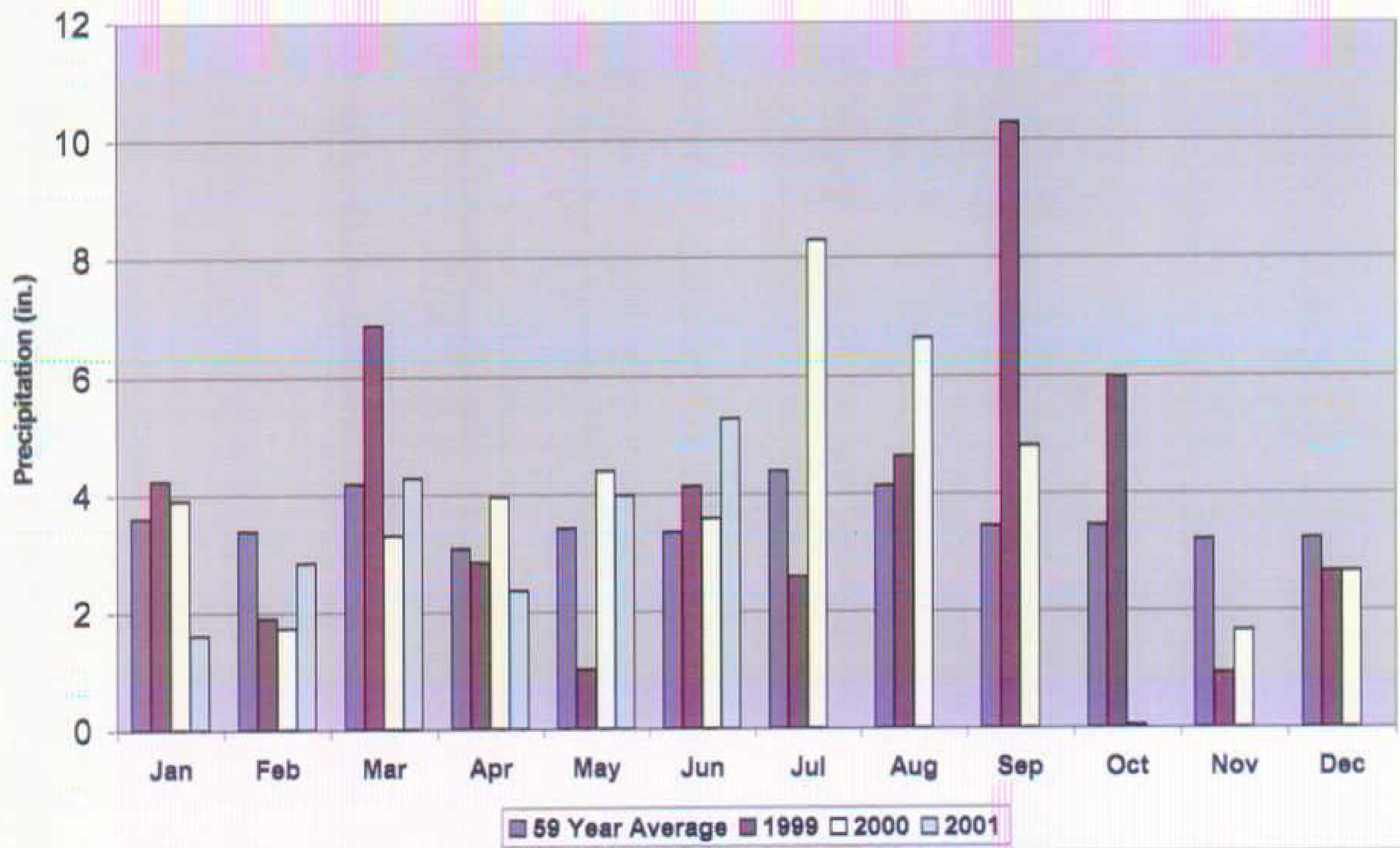
34'

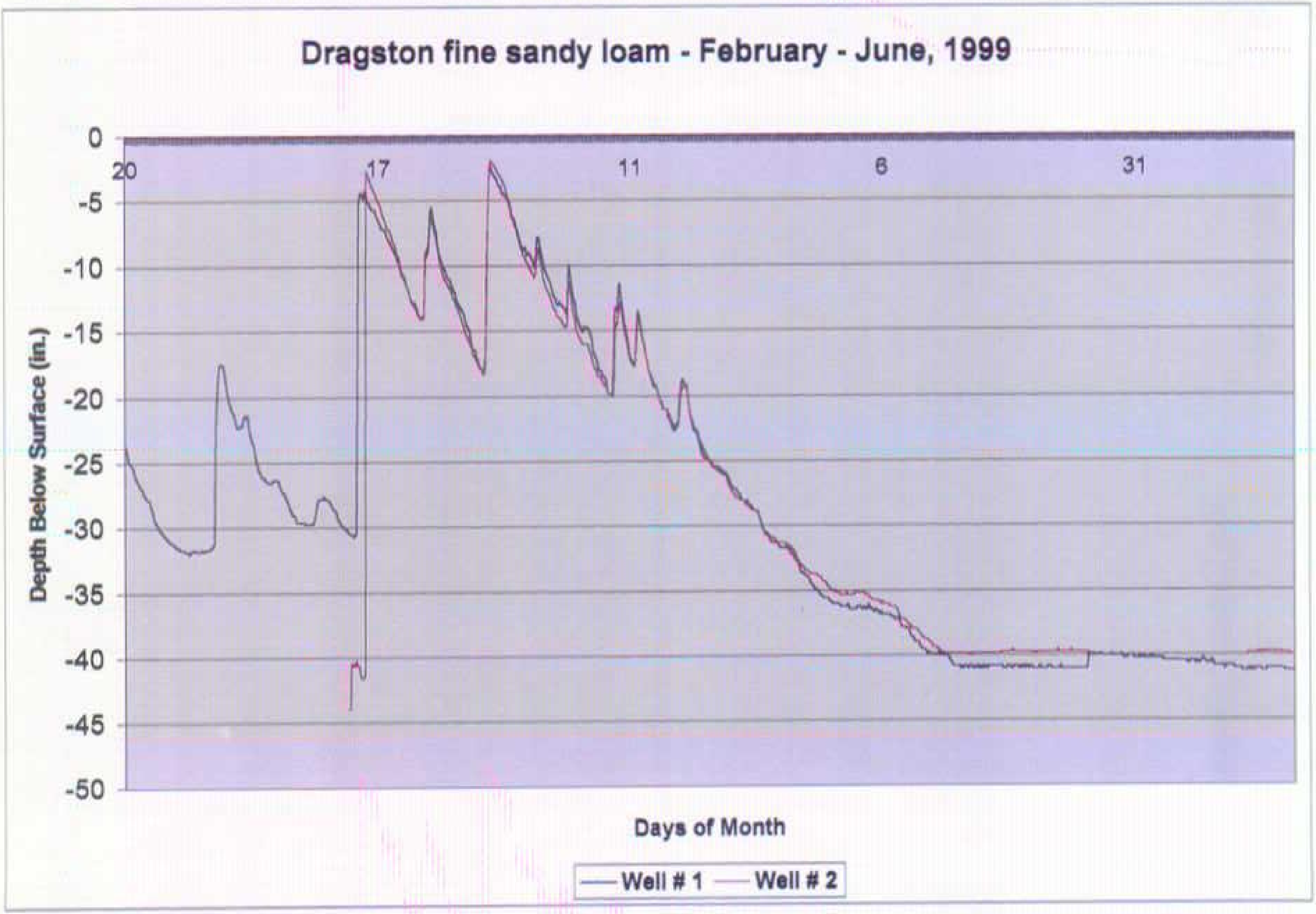
Data I_o~er #1
WL-40 !,8'

Puraflo Pad

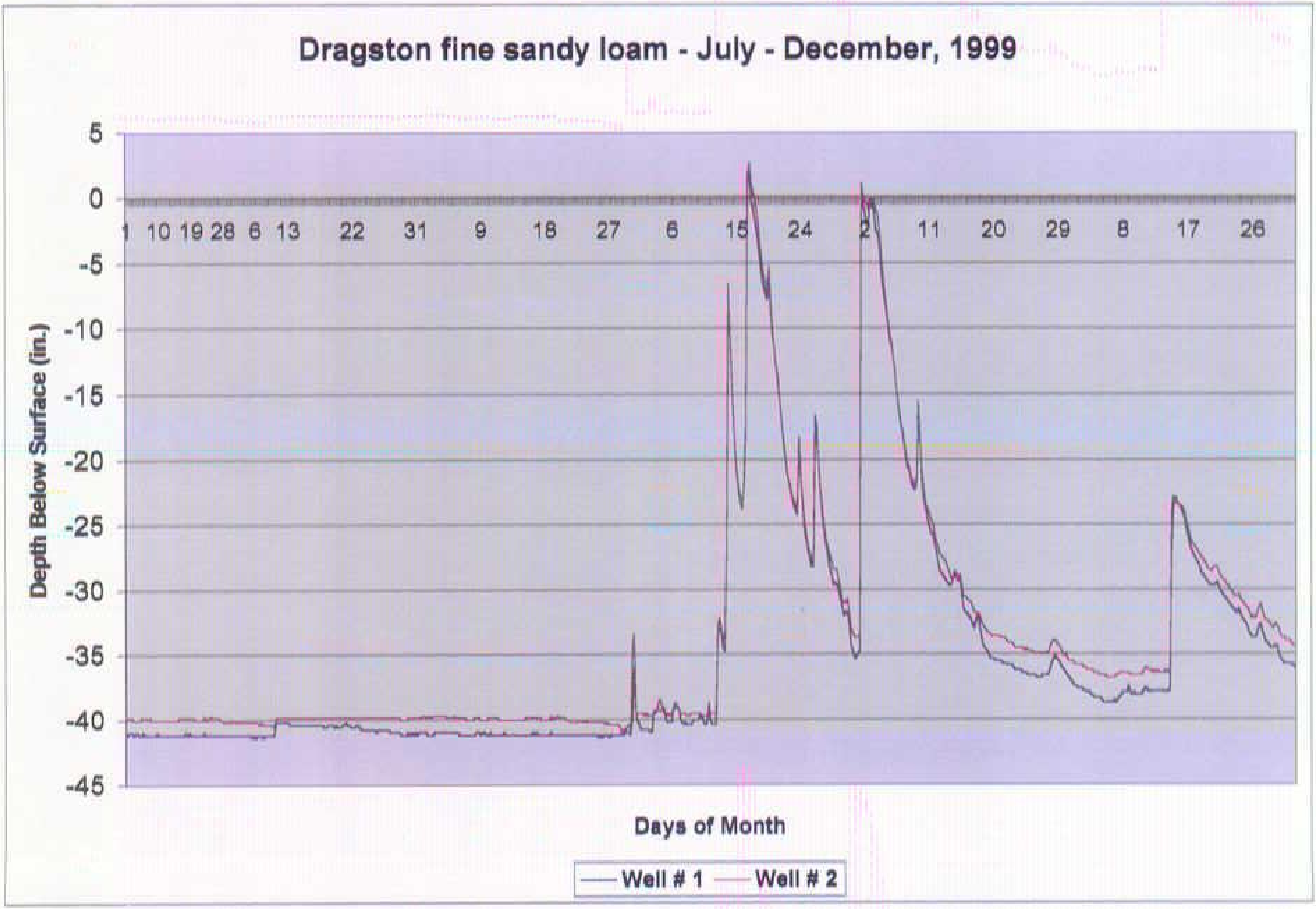

PENN
618
609
Sewage
Disposal
Hospital
WT
BM 35
Cem
600
606
BM 38
Nassawadox
NASSAWADOX
Dragston Fine Sandy Loam
619
BM 37
Cem
617
Weirwood

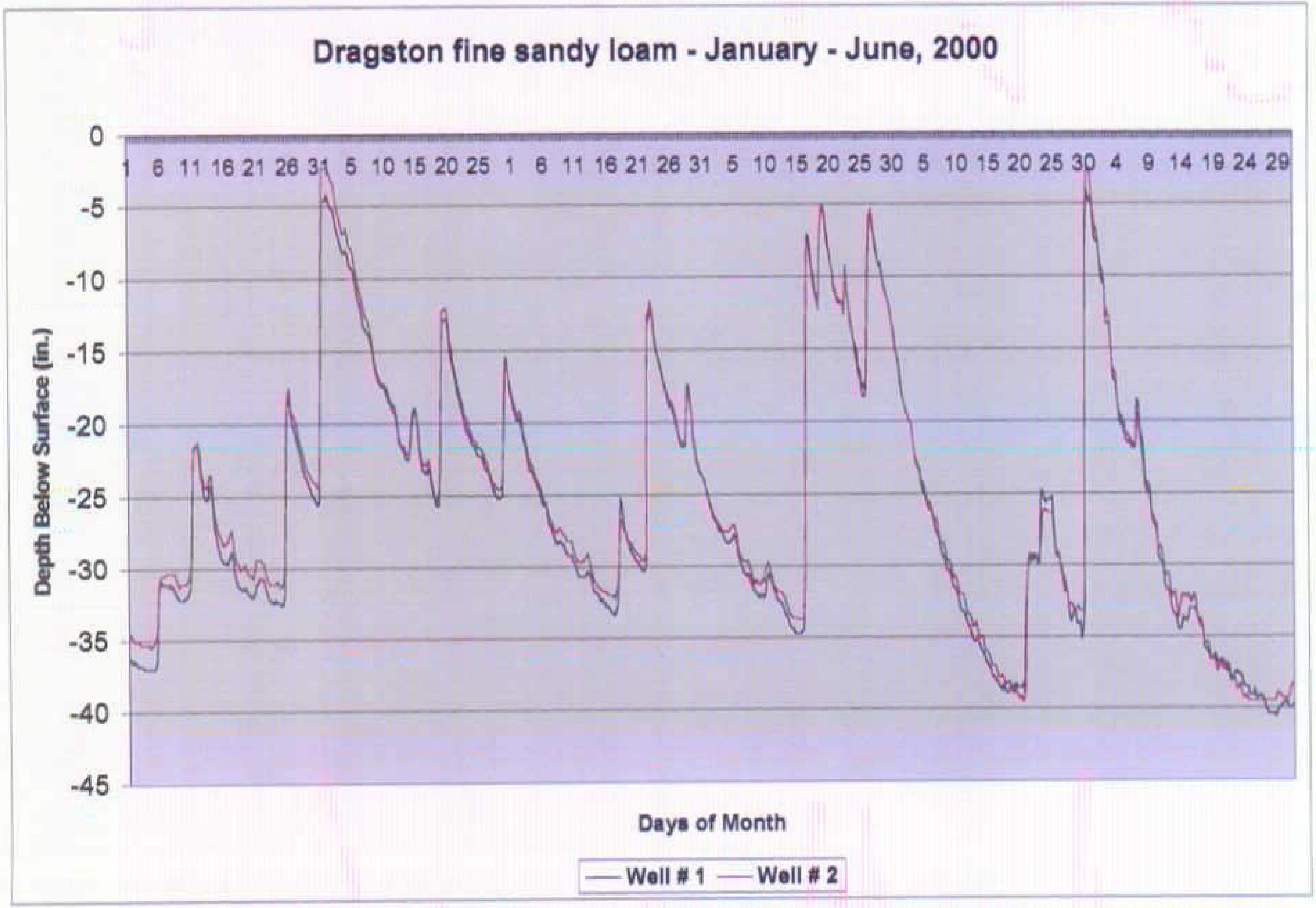
Northampton County Precipitation Comparison



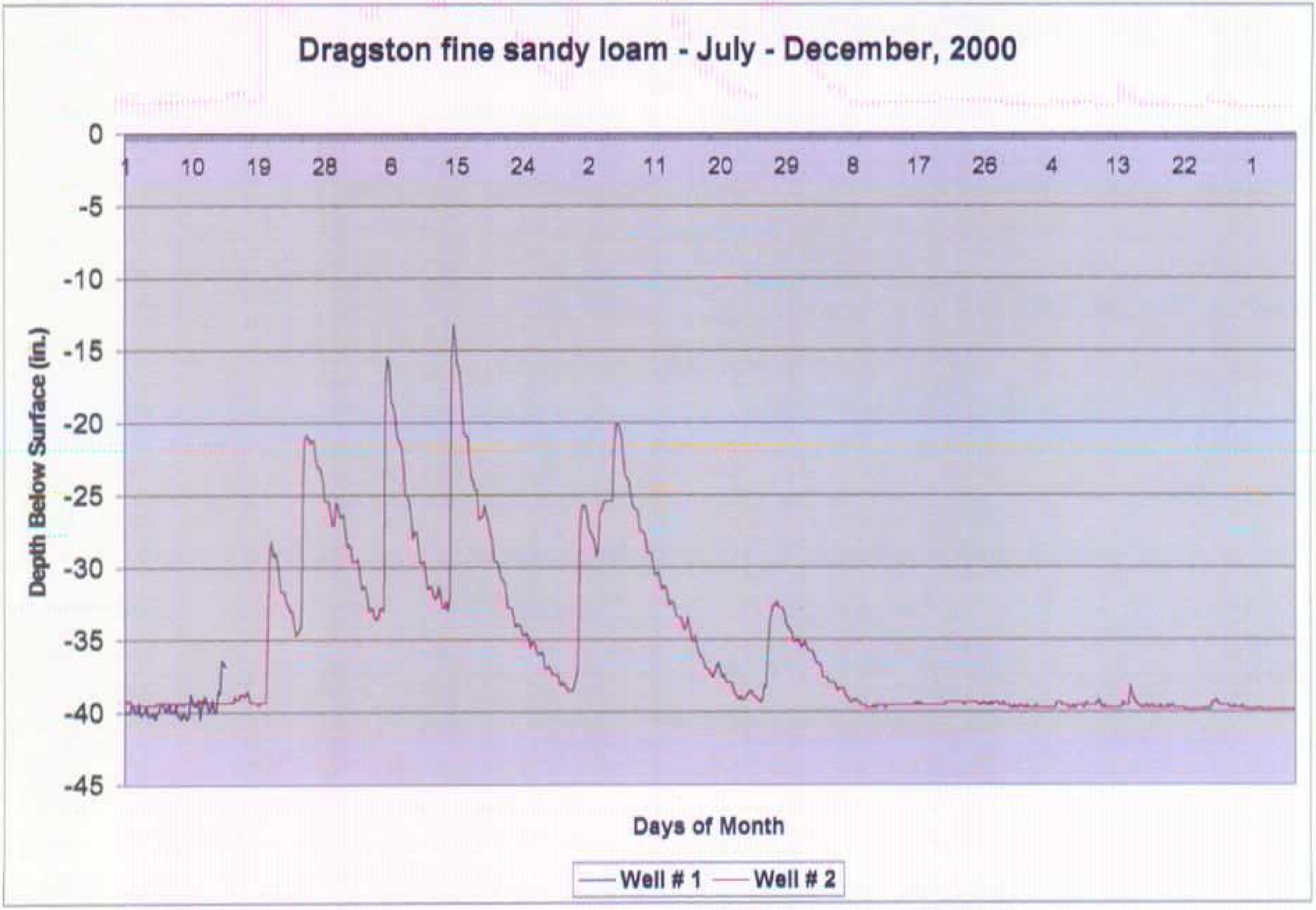


Dragston fine sandy loam - February - June, 1999
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
Depth Below Surface (in.)
20
17
11
6
31
Days of Month
Well # 1
Well # 2


Dragston fine sandy loam - July - December, 1999
Depth Below Surface (in.)
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
1 10 19 28 6 13 22 31 9 18 27 6 15 24 2 11 20 29 8 17 26
Days of Month
Well # 1
Well # 2



Dragston fine sandy loam - January - June, 2000
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
Depth Below Surface (in.)
1 6 11 16 21 26 31 5 10 15 20 25 1 6 11 16 21 26 31 5 10 15 20 25 30 5 10 15 20 25 30 4 9 14 19 24 29
Days of Month
Well # 1
Well # 2



Dragston fine sandy loam - July - December, 2000
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
Depth Below Surface (in.)
1
10
19
28
6
15
24
2
11
20
29
8
17
26
4
13
22
1
Days of Month
Well # 1
Well # 2

SOIL EVALUATED: Emporia sandy loam

LOCATION:

This research site was located in the northern portion of Hendco County, Virg!nia. Refer to the accompanying portion of the Yellow Tavern U.S. Geologic Survey topographic map for the general character of the area. The accompanying detailed site sketch shows the location of an automated WL-40 data logger and two manual observation wells.on the residential property.

RATIONALE FOR SITE SELECTION:

There were several reasons for using this site. First, the type of soil at the site, Emporia, represents a major soil type located over large areas in the state. Studying Emporia would provide valuable information that could apply to numerous Coastal Plain sites considered for onsite septic 'systems. Second, while the Emporia soil meets Virginia criteria to allow installation of a conventional drainfield, drainfields in this soil often do not work properly on a year-round basis. And finally, the residence at this site employs an alternative onsite wastewater disposal system, so a water table study would provide information on how well this alternative septic system works in problem soils.

SOIL AND SITE INFORMATION:

The soil at this site formed in moderately fine-textured,' stratified;-.unconsolidated;:: fluvio-marine sediments of the upper Coastal Plain. There was a long, gently sloping hillside that lies upslope of the site. The site was on the lower sideslope, very near a small drainway. The wells were in a small wooded area, while the majority of the upslope area was in fescue-type lawn grasses or mulched landscaped beds.

The Soil Survey of Henrico County, Virginia (John W. Clay, 1975), shows the research site as being mapped as Lynchburg fine sandy loam (Ly). Lynchburg is a somewhat poorly drained soil, while the Emporia soil identified at the site is well drained, so this was an inclusion in the mapping unit.

A detailed soil profile description was made at the Site and is included. When compared to the official soil series description for the Emporia series (refer to the Appendix), the soil at this site falls within the range of characteristics. That means the soil was typical or representative of Emporia soils.

While the soil was suitable for a conventional gravity drainfield, there was insufficient area for the septic system required for a three bedroom house, so a Purafl9 (peat moss) Biofilter system was permitted due to its reduced area requirements. The access lids to the four Puraflo modules were at ground level, so the natural soil at the site was excavated to a depth of about 24 inches, 6 inches of 3/4 -1 inch diameter clean gravel was installed, the modules set on the gravel pad and pipes connected,' and then soil backfill material used to level and landscape the site. The septic system permit was issued by the Virginia Department of Health in Apdl 1998, and the Puraflo system was installed and began use in August 1998.

CLIMATIC DATA FOR THE SITE:

The site was less than 13 miles from the Richmond International Airport, where official NOAA weather data are collected, so precipitation data from the airport was used to evaluate rainfall dudng the study period. The precipitation comparison graph shows how each monthly rainfall total compares to the monthly 29-year averages (1961-1990).

It is apparent that for the November-December 1999 period, precipitation was well below normal. In fact, rainfall was only 42% of the long-term average for that two month span. Therefore, the water table levels at the site would be expected to be shallower (nearer to the surface) during a fall with normal precipitation.

For the period January-May 2000, total precipitation was 18.41 inches, only 0.23 inches above the 29-year average. That means that the water table levels would be expected to be representative of normal conditions at the site.

For the period July-December 2000,~ monthly rainfall was' generally below normal. It is noteworthy that only 0.01 inches of rain was recorded for the entire month of October 2000, making it the driest October since data collection began in 1928 at the Richmond International Airport. The October-December 2000 period had only 4:03 inches of rain, which was extremely dry. In fact, rainfall was only 41% of the long-term average for that 3 month span. That dry fall situation was very similar to moisture conditions noted for November-December 1999. Therefore, the water table levels at the site would be expected to be shallower during a fall with normal precipitation.

For the period January-June 2001., .monthly rainfall was generally below normal. January-May 2001 rainfall was 4.26 inches below the 29-year average, or 25% below normal. Therefore, the water table levels at the site would be expected to be shallower during a winter and spring with normal precipitation.

Except for a few exceptional wet months (April, June and August 2000; and June 2001), precipitation was normal to below normal. It should be noted that the original project completion date was extended due to severe drought conditions in most of the state during 1999. Fall 2000 thru spring 2001 was also well below normal. Therefore, only the January-May 2000 period had near normal preciPitation, while the rest of the study period had below normal rainfall.

RESULTS:
A WL-40 data logger, a shallow manual observation well and a deep manual observation well were installed ten feet from an operating Puraflo wastewater treatment system on June 28,1999. Wells were installed in the same soil, on the same landscape position, and at the same topographic elevation, as the adjacent Puraflo treatment system. The wells were representative of the soil conditions at the Puraflo site, but were remote enough to be unaffected by the septic system. Due to operator error, the automated well was not programmed properly and the collection of water table data did not commence until November 18, 1999. There was continuous data collection from the starting date until June 30, 2001. The manual wells were read only when visiting the site to download data from the data logger. The manual wells were not intended to gather water table data on a frequent basis; instead, they were used mainly as a check to see how closely the automated and manual wells corresponded.

The Emporia soil' at this site had common light gray (10YR 7~2) mottles (or iron depletions) below 43 inches in the Bt4 horizon, making it a well drained soil. Normally, it would be assumed that the seasonal water table would be below 43 inches, while there might be brief periods where it was above that depth. These soils normally have a perched water table. The dense, red mottled Bt4 horizon was restrictive, which was confirmed by the soil profile description remarks made for this site (ie, the Bt4 was only damp while free water rose in the borehole). The mottling at shallower depths in the Bt2 and Bt3 horizons was suspected to be associated with the fluctuating seasona~ water table, perched above the Bt~, horizon.

The water table hydrograph of November-December 1999 shows the presence of free water in the soil at a depth of 35-40 inches for nearly a month, until mid-December. The water level at this depth may relate to the drought in 1999, and that November 1999 precipitation was only ,32% of normal. And while December rainfall was only~53% of normal, there was a sharp rise in depth of free water in the soil to nearly 20 inches below the surface. The water level then dropped in an irregular, spiking pattern down to a depth of about 30 inches.

The November-December 1999 Groundwater Data Table shows that the surface of the free water was in the Bt2 horizon 17 days, or 39% of'the time during this 44 day period. Free water was in the Bt3 horizon 100% of the time. During this drought period, the seasonal water table was always shallower than the depth to gray mottles in the soil, and there was always free water in the Bt3 horizon.

The January-June 2000 hydrograph shows the water table fluctuated between depths of 15 to 32 inches below the soil surface from January thru early May. A rapid drop in the free water level starting in early May corresponds to shrubs and trees leafing-out and a rapid increase in the evapotranspiration at the site. The data logger remained dry for part of May and all of June, except for a few spikes of rapid water table rise and fall.

The January-June 2000 Groundwater Data Table showed that free water was in the Bt1 hodzon about 16 days or 9% of the time dudng this 182 day period. Free water was only briefly in the E horizon for one day. Free water was in the Bt2 horizon 103 days, or 57% of the time. Free water was in the Bt3 horizon 146 days, or 80% of this monitoring period.

The seasonal water table was shallower than the depth to gray mottles at least 80% of the time for this monitoring period. The reality was that for January 1 thru mid-May, the seasonal water table was always shallower than the depth to gray mottles in the soil, and there was always free water in the Bt3 horizon.

The July-December 2000 hydrograph shows nearly continuous dry hole readings, from July thru mid-December. There was a rapid rise in the water table in mid-December, and free water remained in the monitoring well until the end of the year. The timing of the mid-December spike was very similar to the one seen in the November-December 1999 hydrograph. However, because of dry conditions in October and November 2000, the mid-December spike did not rise to as shallow a soil depth or remain shallow for as long a period.

The July-December 2000 Groundwater Data Table showed that free water was in the Bt2 horizon 3 days, or 2% of the time during this 184 day period. Free water was in the Bt3 horizon for at least 24 days or 13% or this monitoring period.

Another way to look at the data is to consider only the mid-December to December 31 time period. During this 15 day span, water was in the Bt2 horizon for 3 days or 20% of the time, and free water was in the Bt3 horizon for 15 days or 100% of the time. The reality was that. for the last two weeks of December 2000, the seasonal water table was always shallower than the depth to gray mottles in the soil, and there was always free water in the Bt3 horizon.

The January-June 2001 hydrograph shows mainly dry well readings in early January and from early May thru June. There was an exceptional rise in the .free water level in mid-January, rising 29 inches in a 42 hour period. Numerous water table spikes were recorded, with one coming very close to ground surface. There was a rapid drop in the water table from mid-April to early May.

Free water was briefly present in the E horizon during two sharp rises in the water table, and only for 2 days total duration. Water was in the Bt1 horizon about 12 days, for 7% of the time during this 181 day period. The water table was in the Bt2 horizon 74 days or 41% of the time. Free water was in the Bt3 horizon at least 124 days or 68% of this monitoring period.

The seasonal water table was shallower than the depth to gray mottles at least 68% of the time. The reality was that from mid-January thru early May, the seasonal water table was always shallower than the depth to gray mottles in the soil, and there was always free water in the Bt3 horizon.

The included table shows the comparison of automated water level readings to both manual observation wells on specific dates. It should be noted that for this particular data logger, the depth for a dry hole reading varied slightly over the entire test period. The bottom of the shallow manual well was 34 inches below ground surface, and the deep manual well was 48 inches deep.

It is very clear that while all three wells were installed on the same date, in the same soil, and in the same landscape, there were major discrepancies in the measured depths to the water table. There was never a recorded time when any of the three wells had the same, or even generally close readings. The deep manual well consistently had depths to the free water that were at least 3-4 inches deeper than the data logger. The shallow manual well consistently had the depth to free water at least 5 inches deeper than the data logger. While the two manual wells were generally close, the shallow well almost always showed the water table to be at least one inch deeper than the deep well.

CONCLUSIONS:

This site had precipitation levels well below normal for the majority of the study period. In spite of that, the Emporia soil had free water present for significant periods of time during the winter and spring. In addition, the depth to free water was much shallower than where gray mottles were observed in the soil. Once the water table rose in the soil, it Stayed up for an extended period of time.

Free water was observed in the E and Bt1 horizons only for short periods of time, and was always associated with precipitous rises in the water table. For the entire study period, free water was in these horizons about 28 days, though not continuously. There were no soil morphologic features that could be related to the presence of water in the soil for the number of days observed. In other words, there was no clue that this soil could be wet at such shallow depths. Under normal precipitation it would be expected that the seasonal water table would be in the E and Bt1 horizons for significantly longer periods of time.

Free water was observed in the Bt2 horizon for extended periods of time. Except for the November-December 1999 period, water in the Bt2 horizon was characterized by sharp rises and more gradual drops. For the entire study period, the surface of the free water was in the Bt2 horizon about 197 days.

To really understand how wet the soil was, it should be noted that from mid-November 1999 thru June 2000 the soil was almost continuously saturated. During this normally wetter time of the year, the surface of the free water was present in the Bt2 horizdn for 120 days or 53% of the time. From mid-December 2000 thru June 2001, the surface of the free water was present in the Bt2 horizon for 77 days or 39% of the time.

The presence of common, strong brown redoximorphic features (mottles) in the Bt2 horizon reflects the presence of the seasonal water table for extended periods of time. During the normally wetter times of the year, for two years in a row, the seasonal water table was present in the Bt2 horizon from 1/3 to 1/2 of the time. It is expected that under normal precipitation, the seasonal water table WoUld be in the strong brown mottled Bt2 horizon for longer periods of time.

It must be remembered that when the surface of the water table was in one of the upper horizons, the Bt3 horizon was saturated. Free water was observed in the Bt3 horizon for extended periods of time. For the entire study period, free water was in the Bt3 horizon at least 338 days. The mid-November 1999 thru June 2000 period showed free water in the Bt3 horizon for 190 days or 84% of the time. From mid-December 2000 thru June 2001, free water was present in the Bt3 horizon for 139 days or 70% of the time.

The presence of strong brown, very pale brown and light yellowish brown redoximorphic features (mottles) in the Bt3 horizon reflects the presence of the seasonal water table for extended periods of time. During the normally wetter times of the year, for two years in a row, the Bt3 horizon was saturated or had some free water in it at least 2/3 to 3/4 of the time. It can only be expected that under normal precipitation, the seasonal water table would be in the strong brown and very pale brown and light yellowish brown mottled Bt3 horizon for longer periods of time. ,

The presence of mottles clearly relates to the duration of soil wetness. The Bt1 horizon was saturated for only brief periods and no mottles were observed. During the winter-spring periods, there was a seasonal water table in the Bt2 horizon for 1/3 to 1/2 of the time, and there were common strong brown mottles present. During the winter-spring periods, there was a seasonal water table in the Bt3 horizon for 2/3 to 3/4 of the time, and there were common strong brown and very pale brown and light yellowish brown mottles present. During the normally wetter times of the year, the seasonal water table will be significantly, closer to the ground surface than the depth to gray mottles in the soil, for extended periods of time.

The location of this site on a lower sideslope, with a long upslope watershed, may have contributed to how wet the soil was. During the winter-spring periods when plants were dormant and evapotranspiration was very Iow, groundwater not held in the soil moved downslope towards this site. It is possible that the same soil, Emporia, might be drier if it had been located farther upslope. ~

As was noted earlier, this soil met state requirements for a conventional gravity drainfield, based on soil morphology and landscape position. Based on the two winter-spring monitoring pedods studied, it is apparent that if a conventional septic system had been installed, the gravel filled trenches (at a depth of 18 inches) would have been inundated with free water for bdef periods. Based on the state sewage regulations in effect when the permit was issued, a 15 inch zone of suitable soil beneath the gravel filled trenches would have been required (the "stand-off zone") for treatment and disposal of the wastewater. Based on this research, the seaSonal water table would have been in the "stand-off zone" at least 1/2 to 2/3 of the time during a winter-spring period. Although soil morphology indicated this soil was suitable for a conventional gravity drainfield, two years of water table data taken while there was below normal precipitation, showed the soil was unsuitable.

A Puraflo Biofilter system was installed at this site, and it required a "stand-off zone" of 12 inches beneath the gravel pad it sits upon. Based on an installation depth of 18-24 inches, the seasonal water table would have periodically risen into the Puraflo modules. Based on this research, the seasonal water table would have been in the "stand;off zone" at least 1/2 to 2/3 of the time during a winter-spring period. During a recent conversation with the owner, he said they have never had any trouble with their Puraflo systeml So, while the Puraflo system appeared to operate properly, extended periods of saturation in the "stand-off zone" below the gravel pad may have resulted in incomplete treatment of wastewater, rapid transport of pathogenic organisms and nutrients away from the site, and contamination of the shallow seasonal water table and nearby surface water in the downslopedrainway. The monitoring data indicate that the Puraflo unit should have been installed at a much shallower depth to ensure proper treatment and disposal of wastewater, even though it met Health Department requirements.

The comparison of automated versus manual observation wells clearly showed, at this site, that they were not in agreement. The three wells never had the same depth to the surface of the free water. Even though they were only 3-5 feet apart, there were times that the water level readings differed by more than 5 inches. This raised questions as to what was the real water table depth, and which well was most accurate.

It was difficult to understand why the three monitoring wells yielded such disparate results, since 'they were in the same soil and on the same landscape, and all wells were installed at the same time, in a similar manner. The · consequence of such disparity is that where wells might be used to assess site suitability for a septic system,' utilizing only one observation well might merit issuing a septic permit while another well in another location might result in a rejection letter being sent. It is recommended that any water table study done to determine drainfield suitability should use multiple wells, to allow for anomalies.

Emporia sandy loam

Soil profile for Well #1

A--0 to 1 inch, very dark grayish brown (10YR 3/2) sandy loam; moderate fine and coarse granular structure; many very fine and common medium roots; friable, deformable, slightly sticky, slightly plastic; moist;

E--lto 11 inches, light yellowish brown (10YR 6/4) sandy loam; few fine round quartz pebbles (4-5 mm size); moderate fine and medium subangular blocky structure; many fine and very fine roots, with roots decreasing with depth until they become common very fine; friable, deformable, slightly sticky, slightly plastic; moist.

Btl~11 to 16 inches, yellowish brown (10YR 5/6) sandy clay loam; moderate fine, medium, and coarse subangular blocky structure; common fine and medium roots; friable, deformable, slightly sticky, slightly plastic; moist.

Bt2--16 to 29 inches, yellowish brown (10YR 5/6) clay loam; few fine round quartz pebbles.(3-4 mm size); common medium distinct strong brown (7.5YR 5/8) masses of iron accumulation; friable to firm, semideformable, moderately sticky, moderately plastic; moist.

Bt3---29 to 43 inches, yellowish brown (10YR 5/8) clay loam; common medium distinct strong brown (7.5YR 5/8) masses of iron accumulation, common medium and coarse prominent very pale brown (10YR 7/3) and few fine distinct light yellowish brown (10YR 6/4) iron depletions; one light gray (10YR 7/2) iron depletion observed along a root at 40 inches; firm to very firm, semideformable, moderately to very sticky, moderately to very plastic; noted soil became denser and harder to auger with increasing depth; soil only damp.

Bt4--43 to 60 inches, strong brown (7.5YR 5/8) clay loam; few fine round quartz pebbles; common medium prominent light .gray (10YR 7/2) and few fine distinct light yellowish brown (10YR 6/4) iron depletions, and common medium prominent red (2.5YR 4/8) masses of iron accumulation; firm, deformable, moderately to very sticky, moderately to very plastic; soil only damp.

Remarks: Soil profile from 0-20 inches described from a pit, auger hole description from 20-60 inches. Profile taken in woods under oak trees. 3-4% slope. Landscape position- lower sideslope, at the bottom of a long gentle sideslope. Profile described on December 23, 1999. Free water began appearing on the outside of the auger buckey below 43 inches, yet the soil horizon was only damp. The water level quickly rose in the hole to a depth of 29 inches below land surface, and stabilized at that level, for the remainder of the site visit.

Table I - - Emporia sandy loam Groundwater Data Table
November-December, 1999 (44Days)
Ryall Road, Data Logger Well # 1

Well # 1

· Depth Range (in.)	Number of Days	Percent Time	Cumulative Days	Percent Cumulative Days
0-6	0	0	0	0
6.1-12	0	0	0	0
12.1-18	0	0	0	0
18.1-24	5	11	5	11
24.1-30	12	27	17	39
30.1-36	16	36	33	75
36.1-40	11	25	44	100
Dry	......			

Table 2 - - Emporia sandy loam Groundwater Data Table
January- June, 2000 (182 Days)
Ryall Road, Data Logger Well # 1

Well # 1

Depth Range (in.)	Number of Days	Percent Time	Cumulative Days	Percent Cumulative Days
0-6	0	0	0	0
6.1-12	I	1	1	1
12.1-18	15	8	16	9
18.1-24	43	24	59	33
24.1-30	44	24	103	57
30.1-36	27	15	130	72
36.1-40	16	9	146	80
Dry	36	20	182	100

Number of Days column refers to the number of days the surface of the free water was present within the depth range.
Percentage of Time column refers tO the percent of time the water was present within the 'depth range.
Cumulative Days column refers to the total number of days the water was present within the depth range.
Percentage of Cumulative Days refers to the percent of total time the water was present within

the depth range.
DRY corresponds to the number of readings (converted to days) where the monitoring well recorded no water in the hole.
Days in the column headings corresponds to the number of data logger readings within a depth range divided by the number (normally 2, 4 or 8) of data logger readings per day.

Table 3 - - Emporia sandy loam Groundwater Data Table

July - December, 2000 (184 Days)

Ryall Road, Data Logger Well # 1

Well # 1

Depth Range (in.)	Number of Days	Percent Time	Cumulative Days	Percent Cumulative Days
0-6	0	0	0	0
'6.1-12	0	0	0	0
12.1-18	0	0	0	0
18.1-24	0	0	0	0
24.1-30	3	2	3	2
30.1-36	10	5	13	7
36.1-40	11	6	24	13
Dry	160	87	184	100

Table 4 - - Emporia sandy loam Groundwater Data Table

January-June, 2001 (181 Days)

Ryall Road, Data Logger Well # 1

Well # 1

Depth Range (in.)	Number of Days	Percent Time	Cumulative Days	Percent ' Cumulative Days
0-6	0	0	0	0
6.1-12	2	1	2	1
12.1-18	10	5	12	7
18.1-24	16	9	28	16
24.1-30	46	25	74	41
30.1-36	29	16	103	56
36.1-40	21	12	124	68
Dry	57	32	181	100

Number of Days column refers to the number of days the surface of the free water was present within the depth range.
Percentage of Time column refers to the percent of time the water was present within the depth range.
Cumulative Days column refers to the total number of days the water was present within the depth range.
Percentage of Cumulative Days refers to the percent of total time the water was present within the depth range.

DRY corresponds to the number of readings (converted to ,days) where the monitoring well recorded no water in the hole.
Days in the column headings corresponds to the number of data logger readings within a depth range divided by the number (normally 2, 4 or 8) of data logger readings per day.

AUTOMATED versus MANUAL WATER TABLE READINGS

Date	· Well #1 Reading (in.)	Shallow Manual Well Reading (in.)	Deep Manual Well Reading (in.)
Nov 18 1999	-35.3	Dry	-39
Dec 7 1999	-35.3	Dry	-39.2
Dec 22 1999	-23.8	-28.8	-29.6
Jan 3 2000	,30	Dry	-33.9
Feb 4 2000	-18.4	-23.1	-21.9
Mar 13 2000	-32.4	Dry	-36.6
Mar 31 2000	-22.7	-28.3	-27
Apr 21,2000	-17.8	-23.6	-22.2
May 11,2000	-39.6	Dry	-44.7
Jun 5,2000	Dry	Dry	-46.8
Jun 26,2000	Dry	Dry	-46.8
Jul 21,2000	Dry	Dry	Dry
Aug 24,2000	Dry	Dry	Dry
Sep 22,2000	Dry	Dry	Dry.
Oct 19,2000	Dry	Dry	Dry
Nov 27,2000	Dry	Dry	Dry
Jan 5,2001	-39.4	Dry	-44.7
Mar' 1,2001	-26.7	-32	-30.9
Apr 18,2001	-30.5	Dry	-35
Jun 4,2001	--34	Dry	-39.5
Jul 26,2001	Dry	Dry	Dry

Ryall Road
Scale 1"= 40'

woods

woods

•l' garage

drainway

j manual

/ ' ~ manual well

• gravel d~veway

ods

42'

~inia p~er

Ryall Road

garage woods
! ·

pump tank

house ~

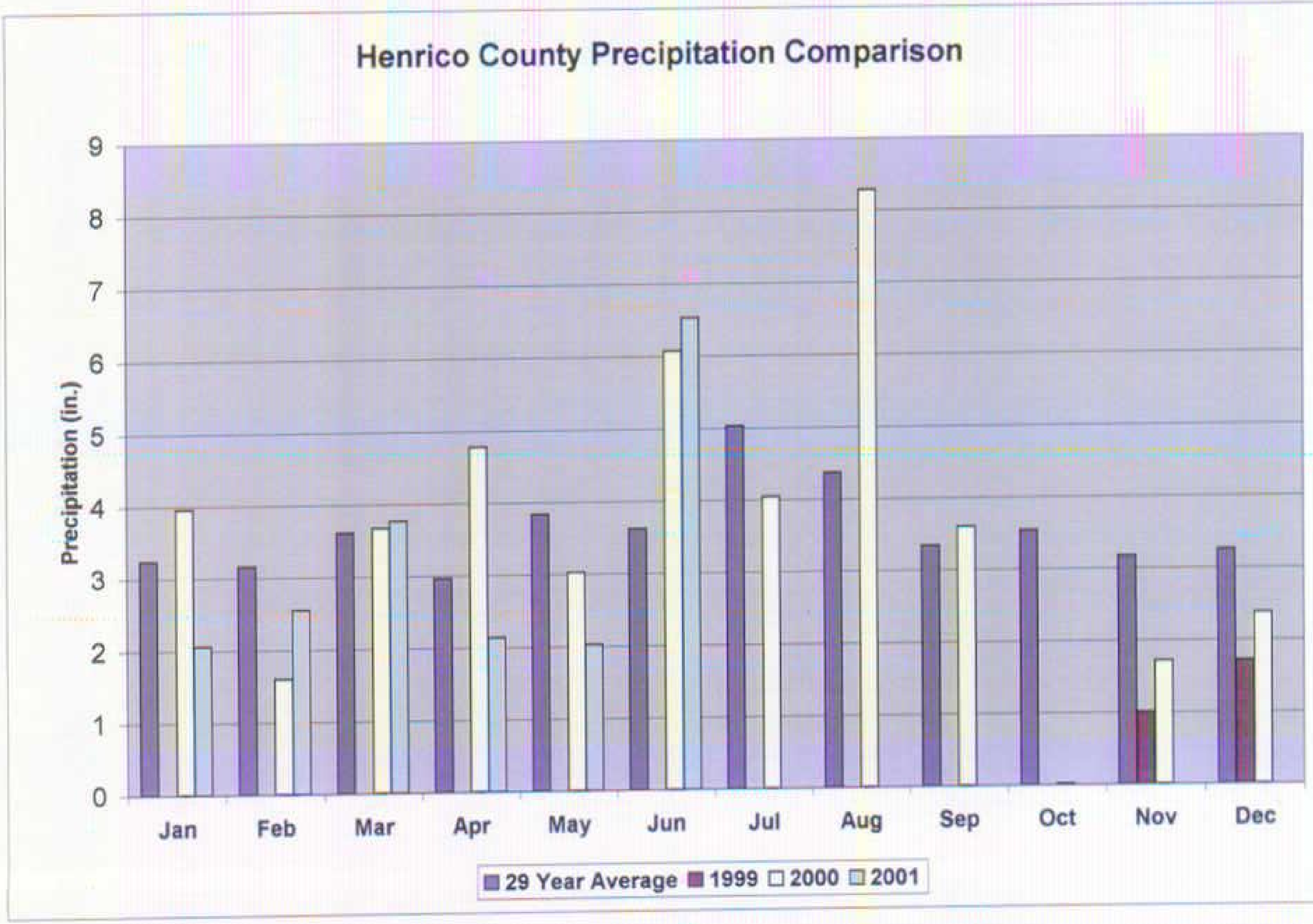
.~ shallow manual well
Well#

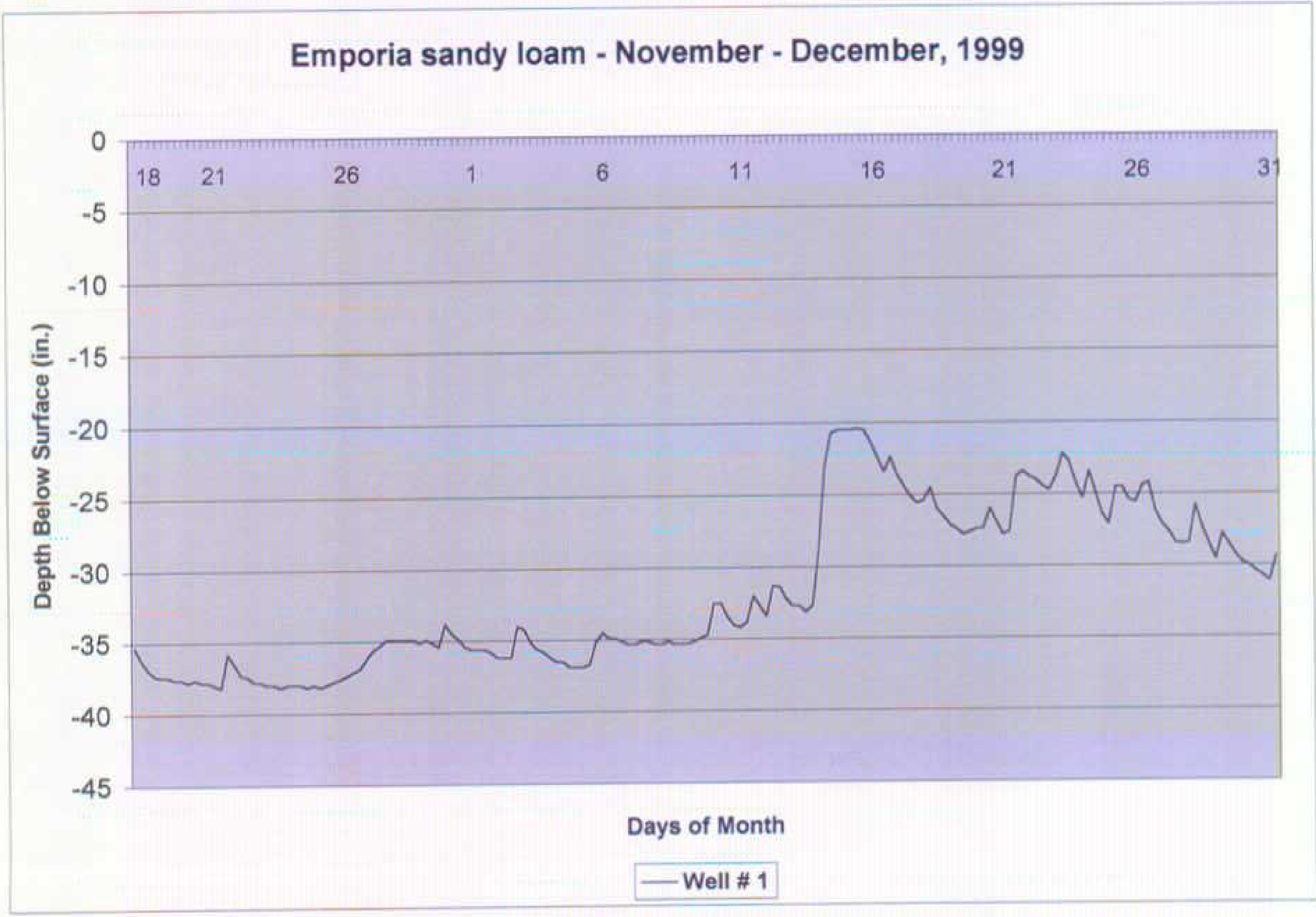
deep manual well

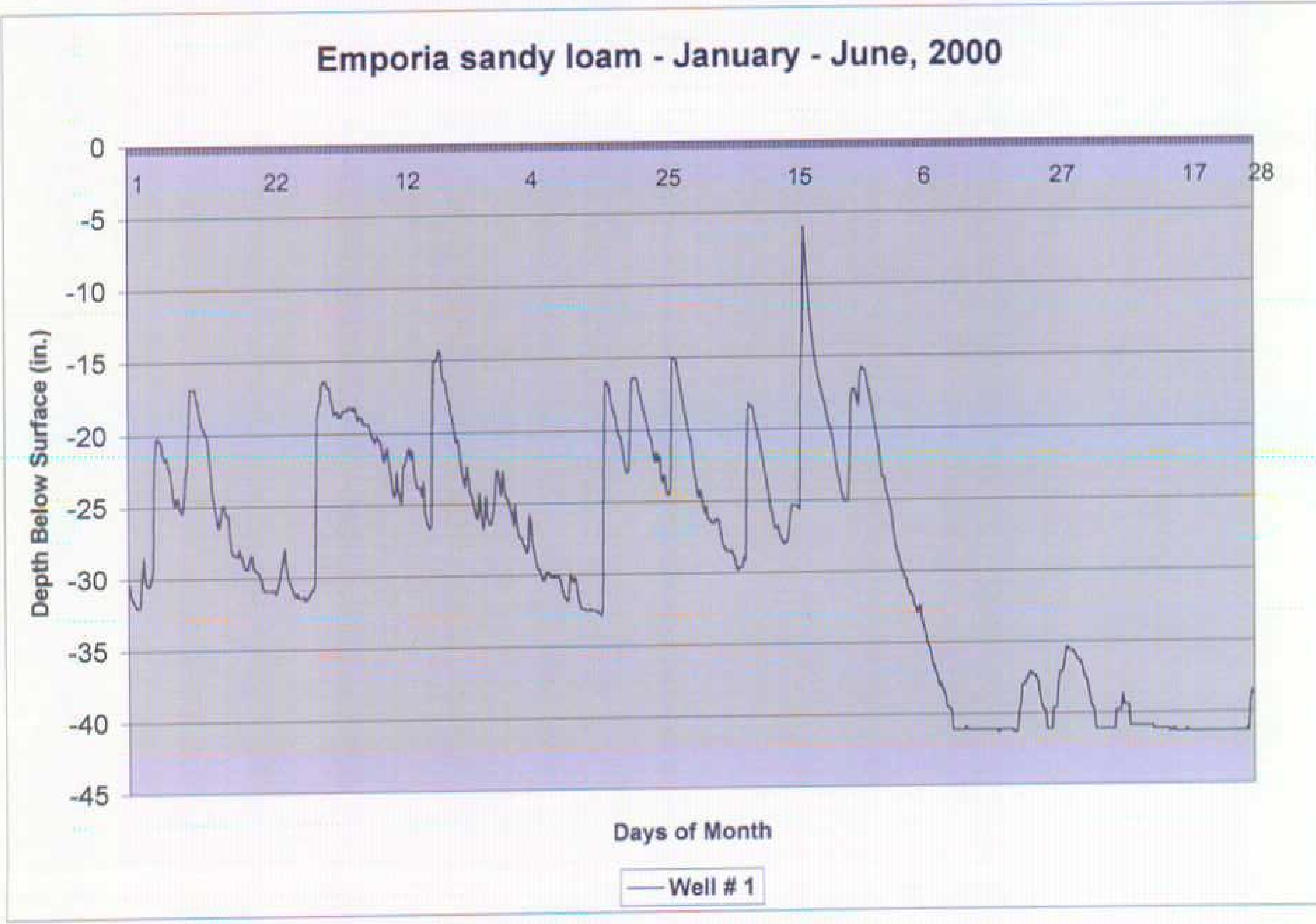
gravel driveway
0

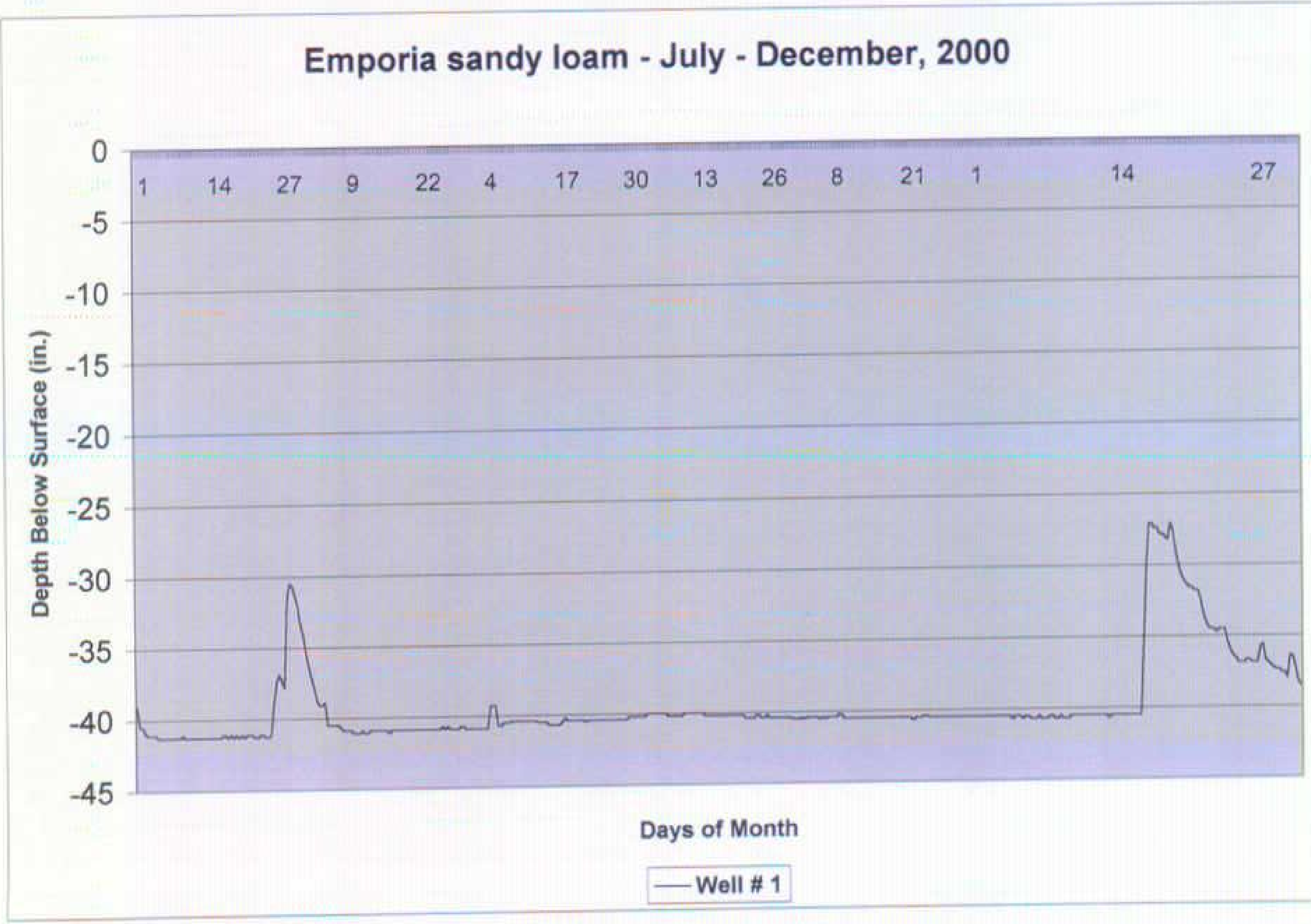
Ryall Road

Hunton
BM 216
625
212
HANOVER CO
HENRICO CO
190
YELLOW TAVERN
Emporia Sandy Loam
200
216
208
295
INTERCHANGE 45
GREENWOOD
207
209
Sewage Disposal

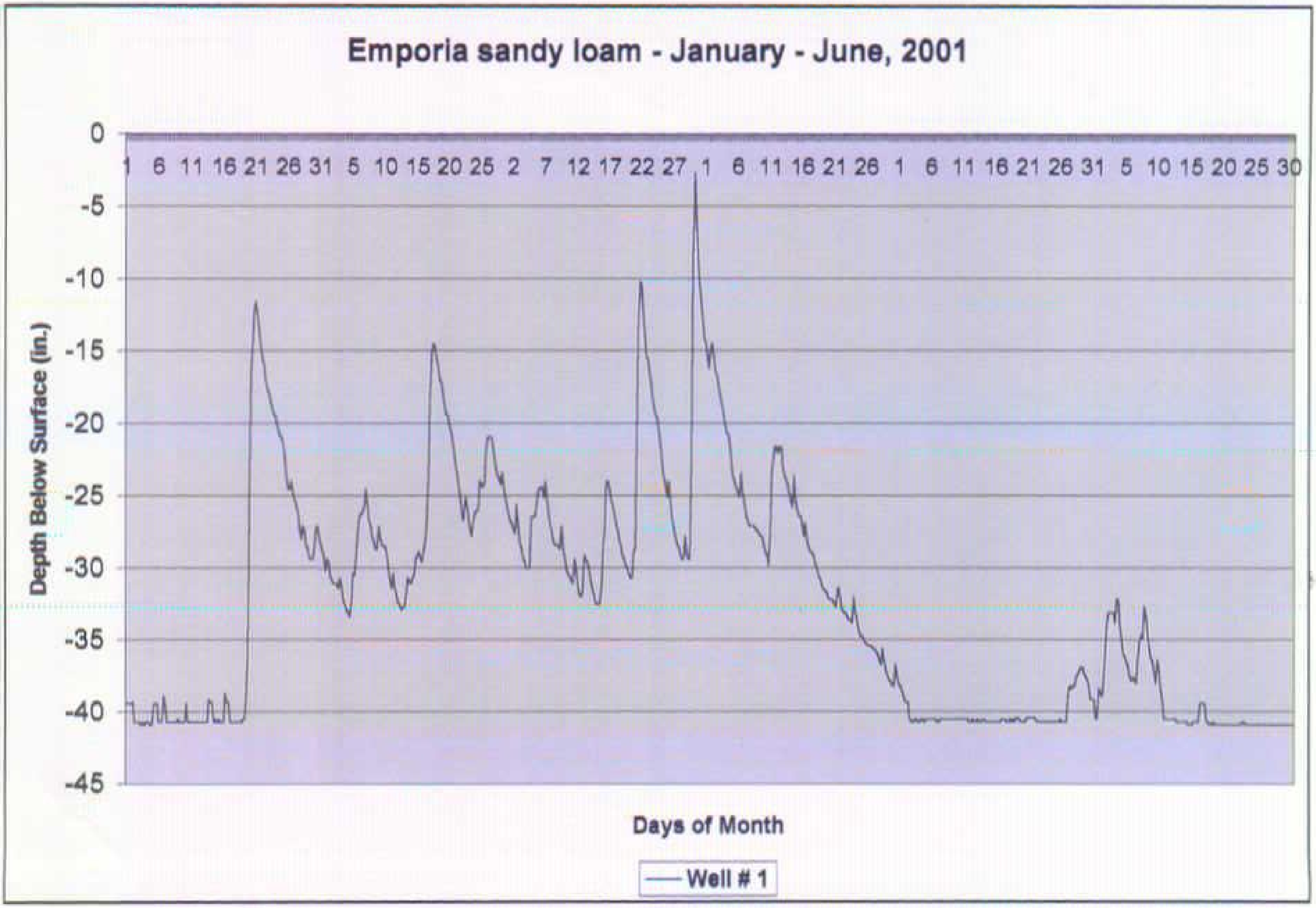

Henrico County Precipitation Comparison
Precipitation (in.)
0
1
2
3
4
5
6
7
8
9
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
29 Year Average
1999
2000
2001


Emporia sandy loam - November - December, 1999
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
Depth Below Surface (in.)
18
21
26
1
6
11
16
21
26
31
Days of Month
Well # 1


Emporia sandy loam - January - June, 2000
Depth Below Surface (in.)
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
1
22
12
4
25
15
6
27
17
28
Days of Month
Well # 1



Emporia sandy loam - July - December, 2000
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
Depth Below Surface (in.)
1
14
27
9
22
4
17
30
13
26
8
21
1
14
27
Days of Month
Well # 1



Emporia sandy loam - January - June, 2001
Depth Below Surface (in.)
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
1 6 11 16 21 26 31 5 10 15 20 25 2 7 12 17 22 27 1 6 11 16 21 26 1 6 11 16 21 26 31 5 10 15 20 25 30
Days of Month
Well # 1

SOIL EVALUATED: Emporia sandy loam

LOCATION:'

This research site was located in the eastern portion of Henrico County, Virginia. Refer to the accompanying portion of the Roxbury U.S. Geologic Survey topographic map for the general character of the area. The accompanying detailed site sketch shows the location of two automated data loggers (a WL-40 and a WL-20) on the residential property.

RATIONALE FOR SITE SELECTION:

There were several reasons for using this site. First, the type of soil at the site, Emporia, represents a major soil type located over large areas in the Coastal Plain. Studying Emporia would provide valuable information that could apply to numerous sites considered for onsite septic systems. Second, while the Emporia soil meets Virginia criteria to allow installation of a conventional drainfleld, drainfields in this soil often do not work properly on a year-round basis. And finally, the residence at this site employs a conventional onsite wastewater disposal system, so a water table study would provide information on how well a septic system might work in problem soils.

SOIL AND SITE INFORMATION:

The soil at this site formed in moderately fine textured,-stratified, unconsolidated, fluvio-marine sediments of the upper Coastal Plain. The site was on a broad, upland position. The wells were in a wooded area adjacent to the drainfield site.

The Soil Survey of Henrico Countv, Vir.qinia (John W. Clay, 1975), shows the research site as being mapped as Kalmia fine sandy loam (KaA). Well drained Kalmia soils have a loamy subsoil and formed on river terraces, while the .Emporia soil identified at the site is also well drained, but has more clay in the subsoil and does not become sand or gravelly sand with depth. Since the Emporia soil series had not been established when the soil survey was completed, the area was included in Kalmia, the most similar soil available.

A detailed soil profile description was made at the site and is included. When compared to the official soil series description for the Emporia series (refer to the Appendix), the soil at this site falls within the range of characteristics. That means the soil was typical or representative of Emporia soils.

While the soil was suitable for a conventional gravity drainfield for a five bedroom house, a pUmp was necessary to lift the sewage uphill to the approved disposal site. The conventional gravity drainfield consisted of 8 trenches, 80 feet long, 3 feet wide, 22 inches deep, on 9 foot centers. The monitoring wells were located in the Reserve or Repair Area, to be used at some future date when the original drainfield fails. The septic system permit was issued by the Virginia Department of Health in March 1997, and the system was installed and began use in August 1997.

CLIMATIC DATA FOR THE SITE:

The site was approXimately 7 miles from the Richmond International Airport, where official NOAA weather data are collected, so precipitation data from the airport was used to evaluate rainfall during the study period. The precipitation comparison graph shows how each monthly rainfall total compares to the mOnthly 29-year averages (1961-1990).

It is apparent that for the November-December 1999 period, precipitation was well below normal. In fact, rainfall was only 42% of the long-term average for that two month span. Therefore, the water table levels at the site would be expected to be shallower (nearer to the surface) during a fall with normal precipitation.

For the period January-May 2000, total precipitation was 18.41 inches, only 0.23 inches above the 29-year average. That means that the water table levels would be expected to be representative of normal conditions at the site.

For the period July-December 2000, monthly rainfall was generally below normal. It is noteworthy that only 0.01 inches of rain was recorded for the entire month of October 2000, making it the driest October since data collection began in 1928 at the Richmond International Airport. The October-December 2000 period had only 4.03 inches of rain, which was extremely dry. In fact, rainfall was only 41% of the long-term average for that 3 month span. That dry fall situation was very similar to moisture conditions noted for November-December 1999. Therefore, the water table levels at the site would be expected to be shallower during a fall with normal precipitation.

For the period January-June 2001, monthly rainfall was generally below normal. January-May 2001 rainfall was 4.26 inches below the 29-year average of 16.81 inches, or 25% below normal. Therefore, the water table levels at the site would be expected to be shallower during a winter and spring with normal precipitation.

Except for a few exceptional wet months (April, June and August 2000; and June 2001), the overall precipitation situation was one of below normal to near drought conditions. It should be noted that the original project completion date was extended due to severe drought conditions in most of the state during 1999. Fall 2000 thru spring 2001 was also well below normal. Therefore, only the January-

May 2000 period had near normal precipitation, while the rest of the study period had significantly below normal rainfall.

RESULTS:

A shallow and a deep automated data logger were installed within 50 feet of an operating conventional gravity septic system on June 28, 1999. Wells were installed in the same soil, on the same landscape position, and at approximately the same topographic elevation, as the adjacent septic system. The wells were representative of the soil conditions at the drainfield site, but were remote enough to be unaffected by the septic system. Due to operator error, the automated wells were not programmed properly and the collection of water table data did not commence until November 19, 1999. There was continuous data collection from the starting date until June 30, 2001.

The Emporia soil at this site had few light brownish gray (10YR 6/2) mottles below 41 inches in the Bt5 horizon, making it a well drained soil. Normally, it would be aSsumed that the seasonal water table would be below 41 inches, while there might be brief periods where it was above that depth~ These soils normally have a perched water table. The dense, red mottled Bt4 horizon was restrictive, which was confirmed by the soil profile description remarks made for this site. The mottling at shallower depths in the Bt3 and Bt4 horizons was suspected to be associated with the fluctuating seasonal water table.

The water table hydrograph of November-December 1999 shows the soil being generally dry until mid-December. This dry condition may relate to the drought in 1999, and the fact that November 1999 precipitation was only 32% of normal. And while December rainfall was only 53% of normal, there was a sharp rise in the water table to less than 20 inches below the surface. The water level then .. dropped in a gradual, irregular pattern down to a depth of about 30 inches in Well #2 (WL-40).

The November-December 1999 Groundwater Data Table shows that the surface of the free water was in the Bt2 horizon 3 days, or 7% of the time during this 43 day period. Free water was in the Bt3 horizon at least 9 days, or 21% of the time. Free water was in the Bt4 hodzon 17 days or 39% of the time. During this drought pedod, the seasonal water table was shallower than the depth to gray mottles in the soil for 27 days, and there was free water in the Bt4 horizon 63% of the time.

The January-June 2000 hydr°graph shows the water table fluctuated between depths of 0 to 32 inches from January thru early May. Numerous water table spikes were recorded, with several coming very close to the ground surface. A rapid drop in the free water level starting in late April corresponded to trees leafing-out and a rapid increase in evapotranspiration at the site. The data loggers remained dry for most of May and all of June. ~

The January-June 2000 Groundwater Data Table showed that free water was in the A or E horizons 11-17 days during this 182 day period. Free water was in the Bt1 horizon about 42 days or 23% of the time. Free water was in the Bt;?. horizon 77-83 days, or 42-46% of the time. Free water was in the Bt3 hodzon 115 days, or 63% of this monitoring pedod. Free water was in the Bt4 horizon 131 days, or 72% of the time.

The seasonal water table was shallower than the depth to gray mottles at least 72% of the time for this monitoring period. The reality was that for January 1 thru early May, the seasonal water table was always shallower than the depth to gray mottles in the soil, and there was always free water in the Bt4 horizon.

The July-December 2000 hydrograph for Emporia shows nearly continuous dry well readings. There were a series of rapid rises in the water table starting in late August, which ended in late September. The timing of the spikes related to heavy rains in late August.

.' The July-December 2000 Groundwater Data Table showed that free water was in
· ' the Bt1 horizon 1 day during this 184 day period. Free water was in the Bt2. horizon for 3-5 days, or 2-3% of this monitoring period. Free water was in the Bt3 horizon for 5 days or 3% of the time. Free water was in the Bt4 horizon for 18 days, or 10% of the time.

The January-June 2001 hydrograph shows mainly dry well readings in early January and from early May thru June. There was an exceptional rise in the free water level in mid-January, rising 29 inches in a 24 hour period. Numerous water table spikes were recorded, with two coming very close to ground surface. There was a rapid drop in the water table from late April to early May.

Free water was present in the A and E horizons during two sharp rises in the water table, and only for 6-8 days total duration. Water was in the Bt1 hodzon 29-31 days, or 16-17% of the time during this 181 day period. The water table was in the Bt2 horizon 59-69 days or 32-38% of the time. Free water was in the Bt3 horizon at least 78 days or 43% of this monitoring pedod. Free water was in the Bt4 horizon 120 days, or 66% of the time.

The seasonal water table was shallower than the depth to gray mottles at least 66% of the time. The reality was that from mid-January thru early May, the seasonal water table was always shallower than the depth to gray mottles in the soil, and there was always free water in the Bt4 horizon.

CONCLUSIONS:

The Emporia study site had precipitation levels well below normal for the majority of the study period. In spite of that, there was free water present for significant periods of time during the winter and spring. In addition, the depth to free water was much shallower than where gray mottles were observed in the soill Once the water table rose in the soil, it stayed up for an extended Period of time.

Free water was observed in the A and E horizOns only for short periods of time, and was always associated with precipitous rises in the water table. For the entire study period, free water was in these horizons about 17-25 days, though not continuously. There were no soil morphologic features that could be related to the presence of water in the soil for the number of days observed. In other words, there was no clue that this soil could be wet at such shallow depths. Under normal precipitation it would be expected that the seasonal water table would be in the A and E horizons for longer periods of time.

Free water was observed in the Bt1 horizon for 72-74 days during the entire study period, and was always associated with sharp rises in the water table. There were no soil morphologic features that could be related to the presence of water~ in the soil for the number of days observed. In other words, there was no clue that this soil could be wet at such shallow depths. Under normal precipitation it would be exPected that the seasonal water table would be in the Bt1 horizon for longer periods of time.

Free water was observed in the Bt2 horizon for extended periods of time. Water in the Bt2 was characterized by sharp rises and more gradual drops. For the entire study period, free water was in the Bt2 horizon 142-160 days.

To really understand how wet the soil was, it should be noted that from late January thru late April of 2000, free water was present in the Bt2 horizon nearly all the time. And from mid-February thru mid-April of 2001, free water Was present in the Bt2 horizon most of the time. There were no soil morphologic features that could be related to the presence of water in the soil for the number of days observed. In other words, there was no clue that this soil could be wet at such shallow depths. Under normal precipitation it would be expected that the seasonal water table woUld be in the Bt2 horizon for significantly longer periods of time.

Free water was recorded in the Bt3 horizon for 207 days during the study period. From late January thru late April of 2000, and mid-February thru mid-April of 2001, free water was present in the Bt3 horizon all the time.

The presence of common strong brown redoximorphic features (mottles) in the Bt3 reflects the presence of the seasonal water table for extended periods of time. For two years in a row dudng the wettest seasons, the seasonal water table was present in the Bt3 horizon from 1/3 to 2/3 of the time. It can only be expected that under normal precipitation, the seasonal'water table would be in the strong brown mottled Bt3 horizon for longer periods of time.

It must 'be remembered that when the surface of the water table was in one of the upper horizons, the Bt4 hodzon was saturated. Free water was observed in the Bt4 hodzon for extended periods of time. For the entire study pedod, free water was in the' Bt4 horizon at least 296 days. The January-June 2000 pedod showed free water in the Bt4 hodzon for 131 days or 72% of the time. F.or January-June 2001, free water was present in the Bt4 horizon for 120 days or 66% of the time.

The presence of strong brown, very pale brown, and red redoximorphic features (mottles) in the Bt4 reflects the presence of the seasonal water table for extended periods of time. For two years in a row during the wettest seasons, the Bt4 horizon was saturated or had some free water in it at least 2/3 to 3/4 of the time. It can 'only be expected that under normal precipitation, the seasonal water table would be in the strong brown and very pale brown and red mottled Bt4 horizon for longer periods of time.

The presence of mottles clearly relates to the duration of soil wetness. The Bt1 horizon was saturated for only brief periods and no mottles were observed: During the winter-spring periods, there was a seasonal water table in the Bt2 horizon for 1/3 to 1/2 of the time, and no mottles were observed. During the winter-spring periods, there was a seasonal water table in the Bt3 hodzon for 1/3 to 2/3 of the time, and there were common strong brown mottles present. During the winter-spring periods, there was a seasonal water table in the Bt4 horizon at least 2/3 to 3/4 of the time, and there were common strong brown, very pale brown and red mottles present. This data shows that during the normally wetter times of the year, the seasonal water table will be significantly closer to the ground surface than the depth to gray mottles in the soil, for extended periods of time.

The location of this site on a broad, nearly level upland, may have contributed to how wet the soil was. During the winter-spring periods when plants were dormant and evapotranspiration was very Iow, groundwater accumulated in the soil above the restrictive horiZons at this site. It is Possible that the same soil, Emporia, might be drier if it had been located on a more sloping site.

As was noted earlier, this soil met the minimum state requirements for a conventional drainfield, based on soil morphology and landscape position.. Based on the two winter-spring monitoring periods studied, it is apparent that the conventional septic system would have been inundated with free water in the gravel filled trenches for brief periods of time. On several occasions, this researcher walked across the drainfield area during the wet winter periods and noted how "soft" the ground felt, but no water was ever observed at the ground surface. In addition, the owner said the drainfield had not given them any trouble. Based on the state sewage .regulations in effect when the permit was issued, a 15-18 inch zone of suitable soil beneath the gravel filled trenches would have been required (the "stand-off zone") for treatmeni and disposal of the wastewater. Based on this research, the seasonal water table would have been in the "stand-off zone" at least 1/2 to 3/4 of the time during a winter-spring pedod. Although soil morphology indicated this soil was suitable for a conventional drainfield, two years of water table monitoring data taken when there was below normal precipitation, showed the soil was unsuitable.

Emporia sandy loam

Well #1 Profile

A--0 to 2 inches, dark brown (10YR 3/2) sandy Ioami friable, deformable, moderately fluid, slightly sticky, slightly plastic; moist.

E--2 to 8 inches, light yellowish brown (10YR 6/4) sandy loam; friable; deformable, moderately fluid, slightly sticky, slightly plastic; moist.

Bt'l~8 to 13 inches, brownish yellow (10YR 6/6) sandy clay loam; friable, deformable, slightly fluid, moderately to slightly sticky, moderately to slightly plastic; moist.

Bt2--13 to 18 inches, brownish yellow (10YR 6/6) clay loam; friable, deformable, slightly fluid, moderately sticky, moderately to slightly plastic; moist.

Bt3--18 to 27 inches, yellowish brown (10YR 5/6) clay loam (approaching clay); common fine distinct strong brown (7.5YR 5/8) irregular to round shaped masses of iron accumulation spread throughout the horizon; firm, deformable, slightly fluid, moderately sticky, moderately plastic; noted soil became denser and harder to auger with increasing depth; moist.

Bt4--27 to 41 inches, yellowish brown (10YR 5/8) clay loam (approaching clay); common medium distinct strong brown (7.5YR 5/8) and common medium prominent red (2.5YR 4~8) masses of iron accumulation, and common medium distinct very pale brown (10YR 7/4) iron depletions; most mottles are evenly scattered throughout the horizon but the very pale brown mottles are only along surfaces or ped faces; very firm to extremely firm, semideformable, slightly fluid, moderately sticky, moderately to very plastic; soil very dense and must lean on auger to bore deeper in ground; soil only damp.

BtS--~tl to 54 inches, yellowish brown (10YR 5/8) clay loam; common medium distinct strong brown (7.5YR 5/8) and few fine prominent red (2.5YR 5/8) masses of iron accumulation, and few medium & coarse distinct pale brown (10YR 6/3) and few medium prominent light brownish gray (10YR 6/2) iron depletions; the strong brown and red mottles are evenly scattered throughout the horizon but the pale brown and light brownish gray mottles are only along surfaces or ped faces; extremely firm, semideformable, slightly fluid, moderately sticky, moderately plastic; soil very dense and hard to auger; soil only damp.

BC--54 to 60 inches, strong brown (7.5YR 5/8) sandy loam; few medium rounded pebbles; few yellowish brown (10YR 5~4) clayballs (clay loam texture) mixed-in or buried in the sandier matrix, with few medium prominent light gray (10YR 7/2) & few coarse distinct pale brown (10YR 6/3) irregularly shaped iron depletions located within the clayballs; few medium irregular distinct yellowish brown (10YR 5/6) masses of iron accumulation; fdable, deformable, slightly fluid, nonsticky, nonplastic; soil very dense and hard to auger; soil only damp.

Remarks: Auger description from 0-60 inches, taken midway between two dataloggers. Profile taken in woods under oak trees. 1% slope. Landscape position- broad upland flat. Profile described on January 3,2000. Free water began appearing in the hole below 27 inches, but was moving down the hole from above, and the Bt4 was only damp. One inch of water accumulated in the bottom of the hole by the end of the description.

Table I - - Emporia sandy loam Groundwater Data Table
November-December, 1999 (43Days)
Saltwood Place, Data Logger Well # 1 & #2

Well # 1					Well # 2			
		Percent				Percent		
Depth	Number	Percent	Cumulative	Cumulative	Number	Percent	Cumulative	Cumulative
Range (in.)	of Days	Time	Days	Days	of Days	Time	Days	Days
0-6	0	0	0	0	0	0	0	0
6.1-12	0	0	0	0	0	0	0	0
12.1-18	3	7	3	7	1	2	1	2
18.1-24	5	12	8	19	9	21	10	23
24.1-30	....				7	16	17	40
30.1-36	.....				4	9	21	49
36.1-40	....				6	14	27	63
Dry	35	81	43	100	16	37	43	100

Table 2 - - Emporia sandy loam Groundwater Data Table
January- June, 2000 (182 Days)
Saltwood Place, Data Logger Well # 1 & #2

Well # 1					Well # 2			
		Percent				Percent		
Depth	Number	Percent	Cumulative	Cumulative	Number	Percent	Cumulative	Cumulative
Range (in,)	of Days	Time	Days	Days	of Days	Time	Days	Days
0-6	11	6	11	6	17	9	17	9
6.1-12	30	16	42	23	25	14	42	.23
12.1-18	42	23	83	46	35	19	77	42
18.1-24	21	12	104	57	38	21	115	63
24.1-30	.....				8	4	123	68
30.1-36	.....				6	3	129	71
36.1-40	......				'2	1	131	72
Dry	78	43	182	100	51	28	182	100

Number of Days column refers to the number of days the surface of the free water was preSent within the depth range.

Percentage of Time column refers to the percent of time the water was present within the

depth range.
Cumulative Days column refers to the total number of days the water was present within the depth range.
Percentage of Cumulative Days refers to the percent of total time the water was present within the depth range.
DRY corresponds to the number of readings (converted to days) where the monitoring well recorded no water in the hole.
Days in the column headings corresponds to the number of data logger readings within a depth range divided by the number (normally 2, 4 or 8) of data logger readings Per day.

Table 3 - - Emporia sandy loam Groundwater Data Table
July - December, 2000 (184 Days)
Saltwood Place, Data Logger Well # 1 & #2

	Well # 1	Percent			Well # 2	Percent		
Depth Range (in.)	Number of Days	Percent Time	Cumulative Days	Cumu ative Days	Number of Days	Percent Time	Cumulative Days	Cumulative Days
0-6	0	0	0	0	0	0	0	0
6.1-12	1	0	1	0	I	0	I	0
12.1-18	4	2	5	3	2	1	3	2
18.1-24	3	2	8	4	2	1	5	3
24.1-30	....				3	2	8	4
30.1-36	.....				5	3	13	7
36.1-40	......				5	3	18	10
Dry	176	96	184	100	166	90	184	100

Table 4 - - Emporia sandy loam Groundwater Data Table
January-June, 2001 (181 Days)
Saltwood Place, Data Logger Well # 1 & #2

	Well # 1	Percent			Well # 2	Percent		
Depth Range (in.)	Number of Days	Percent Time	Cumulative Days	Cumulative Days	Number of Days	Percent Time	Cumulative Days	Cumulative Days
0-6	6	3	6	3	8	4	8	4
6.1-12	25	14	31	17	21	12	29	16
12.1-18	38	21	69	38	30	16	59	32
18.1-24	10	6	79	44	18	10	78	43
24.1-30	....				18	10	95	52
30.1-36	.....				16	9	111	61
36.1-40	....				9	5	120	66
Dry	102	56	181	100	61	34	181	100

Number of Days column refers to the number of days the surface of the free water was present within the depth range.

Percentage of Time column refers to the percent of time the water was present within the depth range.

Cumulative Days column refers to the total number of days the water was present within the depth range.

Percentage of Cumulative Days refers to the percent of total time the water was present within the depth range.

DRY corresponds to the number of readings (converted to days) where the monitoring well recorded no water in the hole.

Days in the column headings corresponds to the number of data logger readings within a depth range divided by the number (normally 2, 4 or 8) of data logger readings per day.

White Oak Ridge Subdivision

~'~.~ 'shed woods

- riser --'-"------'-----~ ~"~ asphalt

. . . ~e~y :

woods

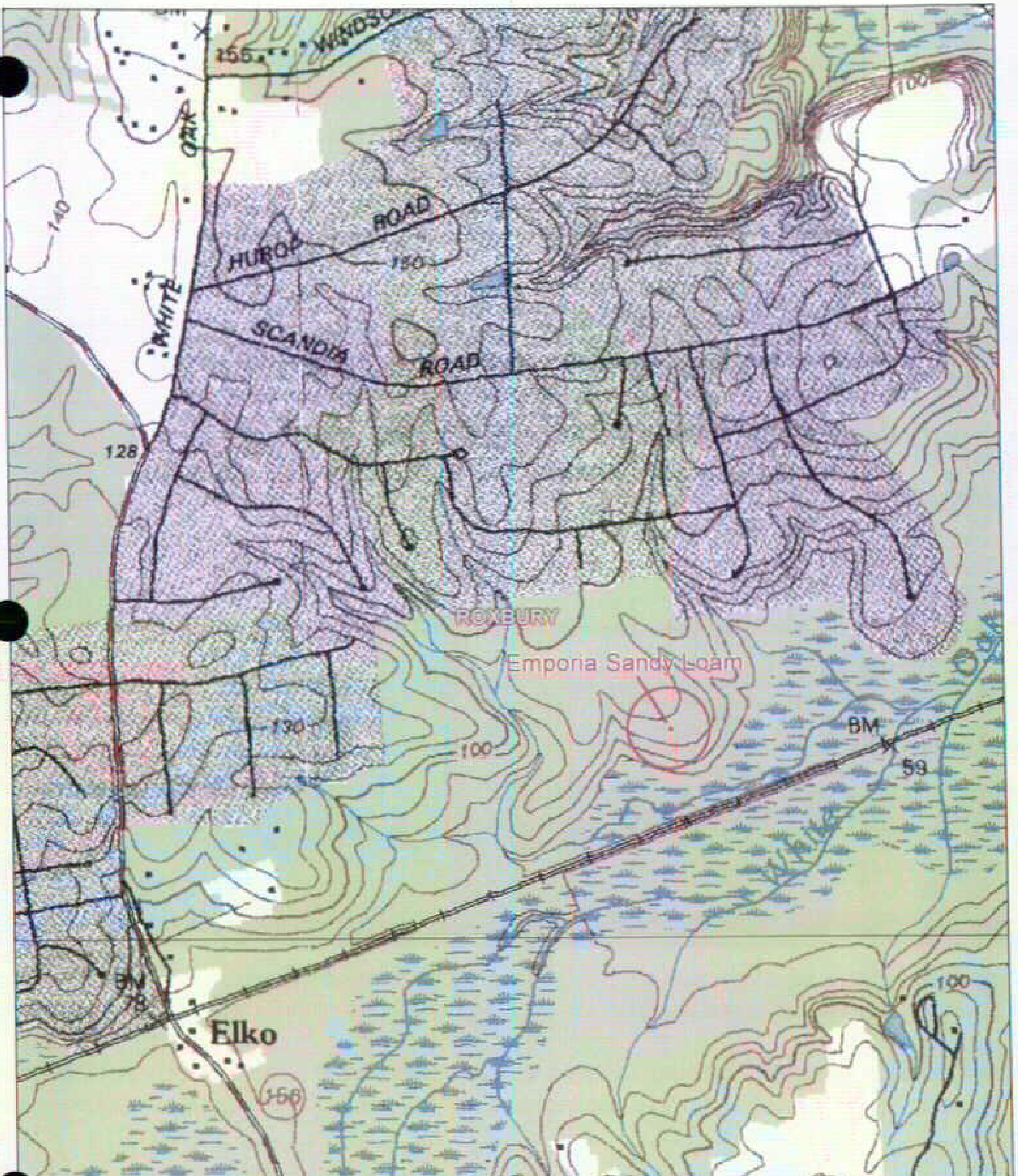
Well#

o /
"fence ~Well#

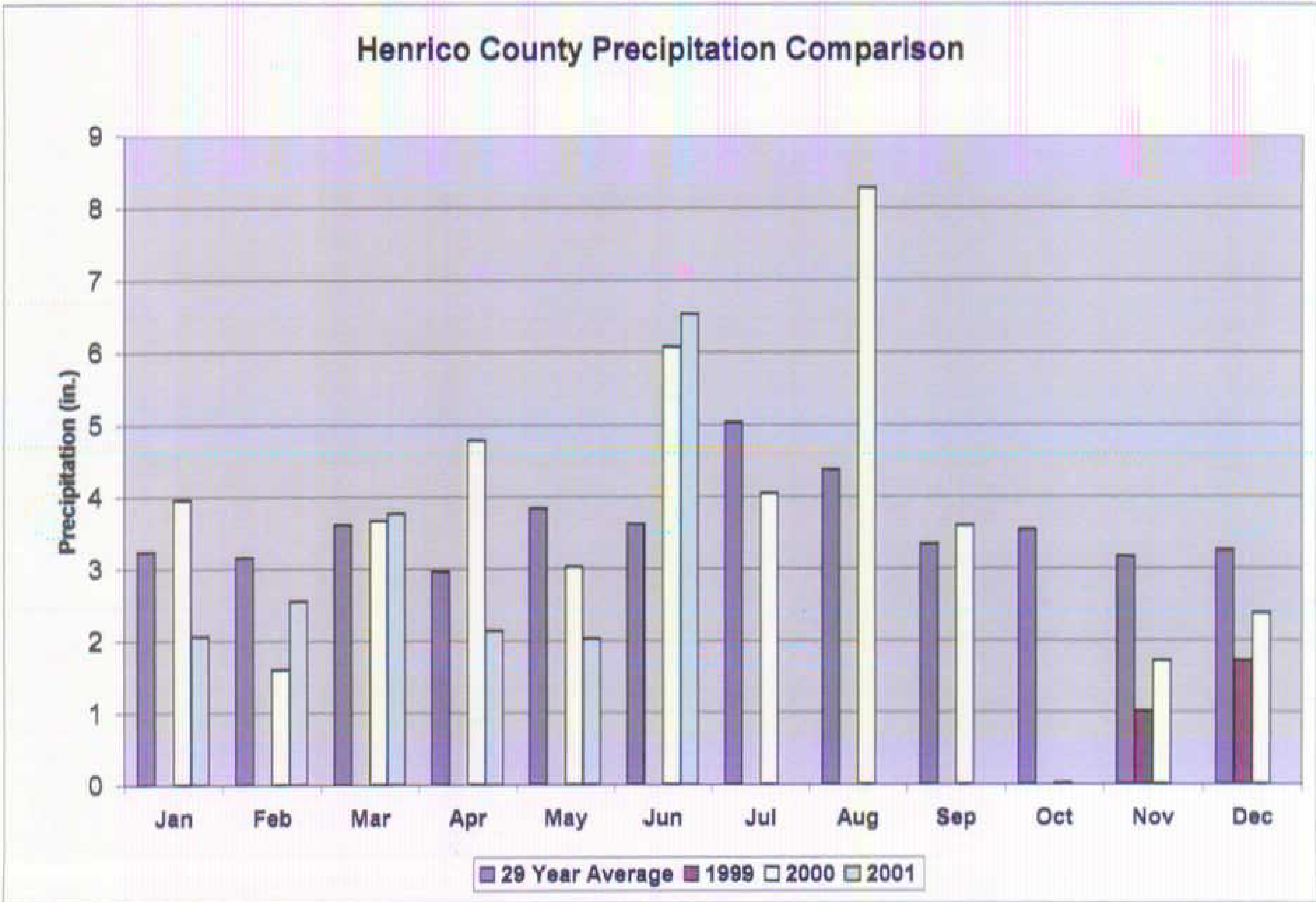
/ Saltwood Place

Existing wOods
Septic
System'
/
fire hydrant

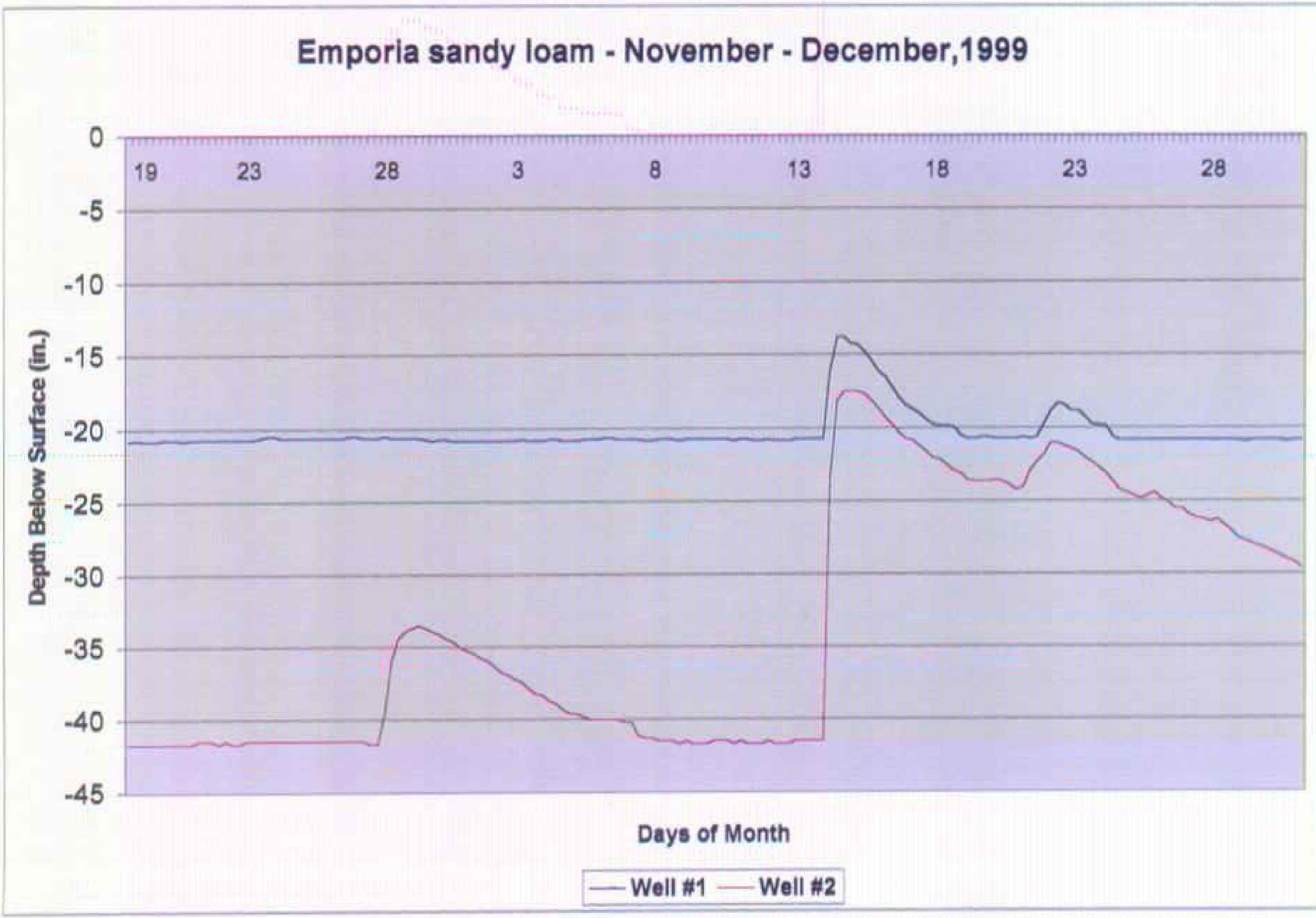
1" = 50'



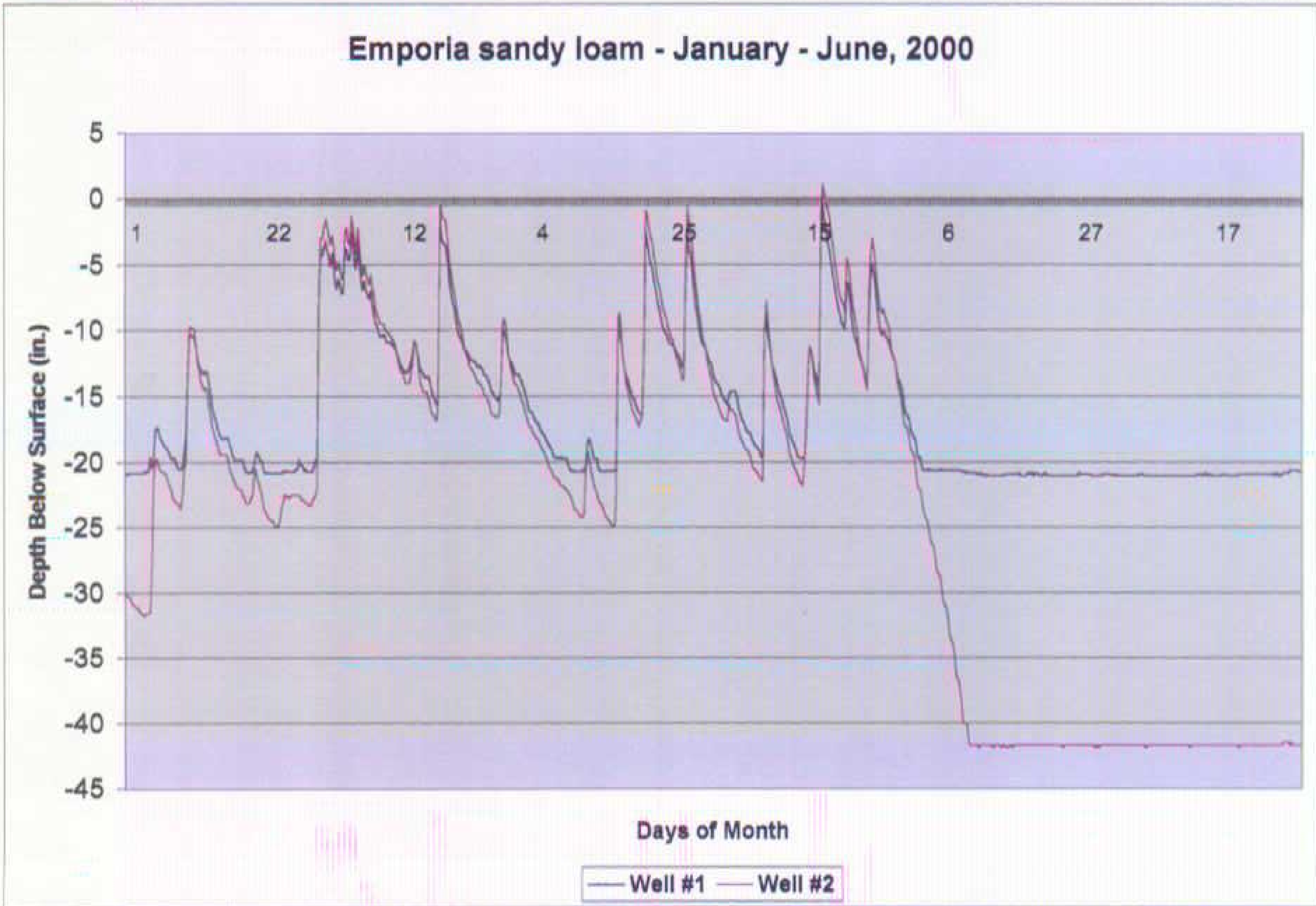
3-D TopoQuads Copyright © 1999 DeLorme Yarmouth, ME 04096 Source Data: USGS 150 ft Scale: 1 : 12,000 Detail: 14-0 Datum: WGS84



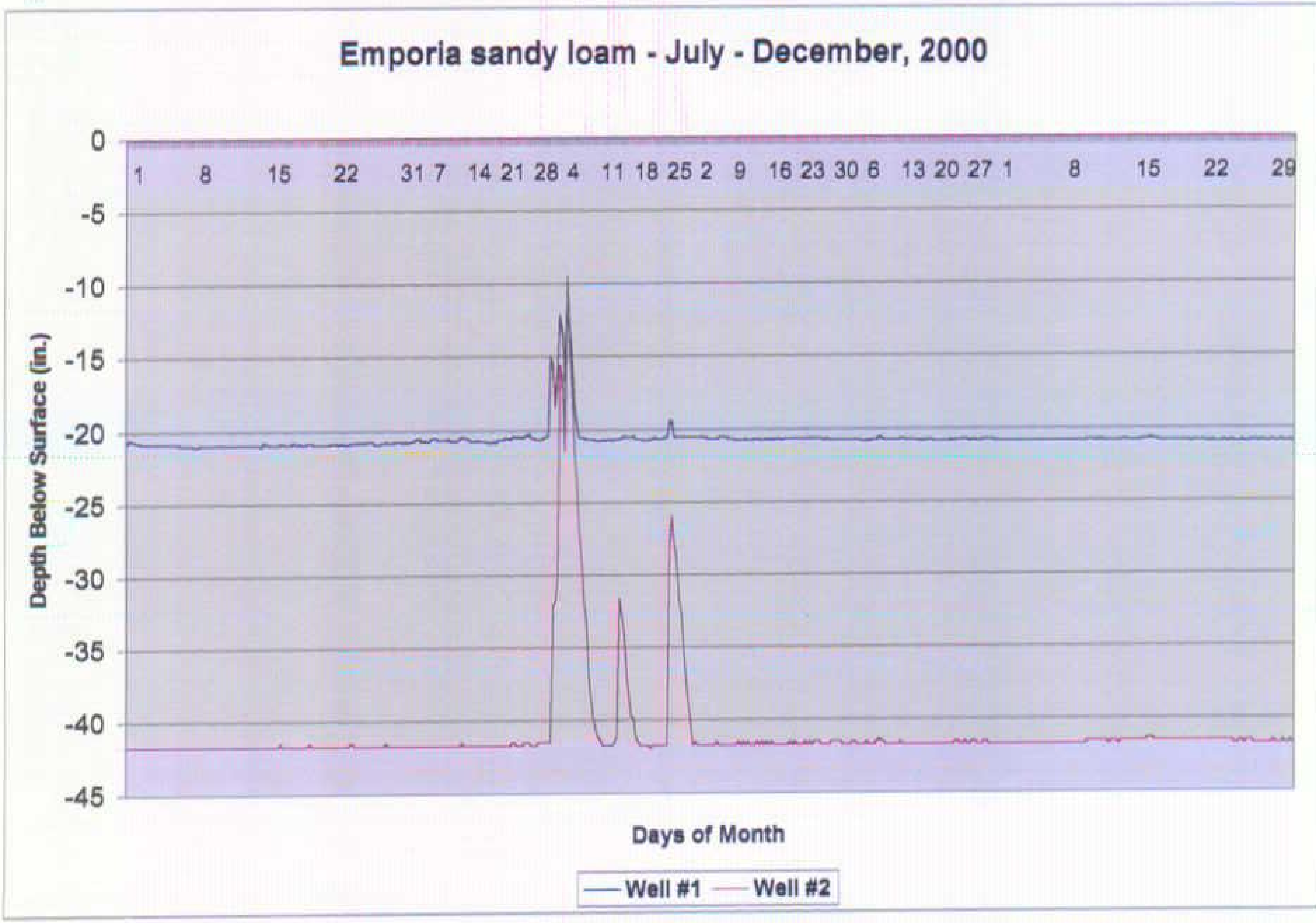
Henrico County Precipitation Comparison
Precipitation (in.)
0
1
2
3
4
5
6
7
8
9
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
29 Year Average
1999
2000
2001



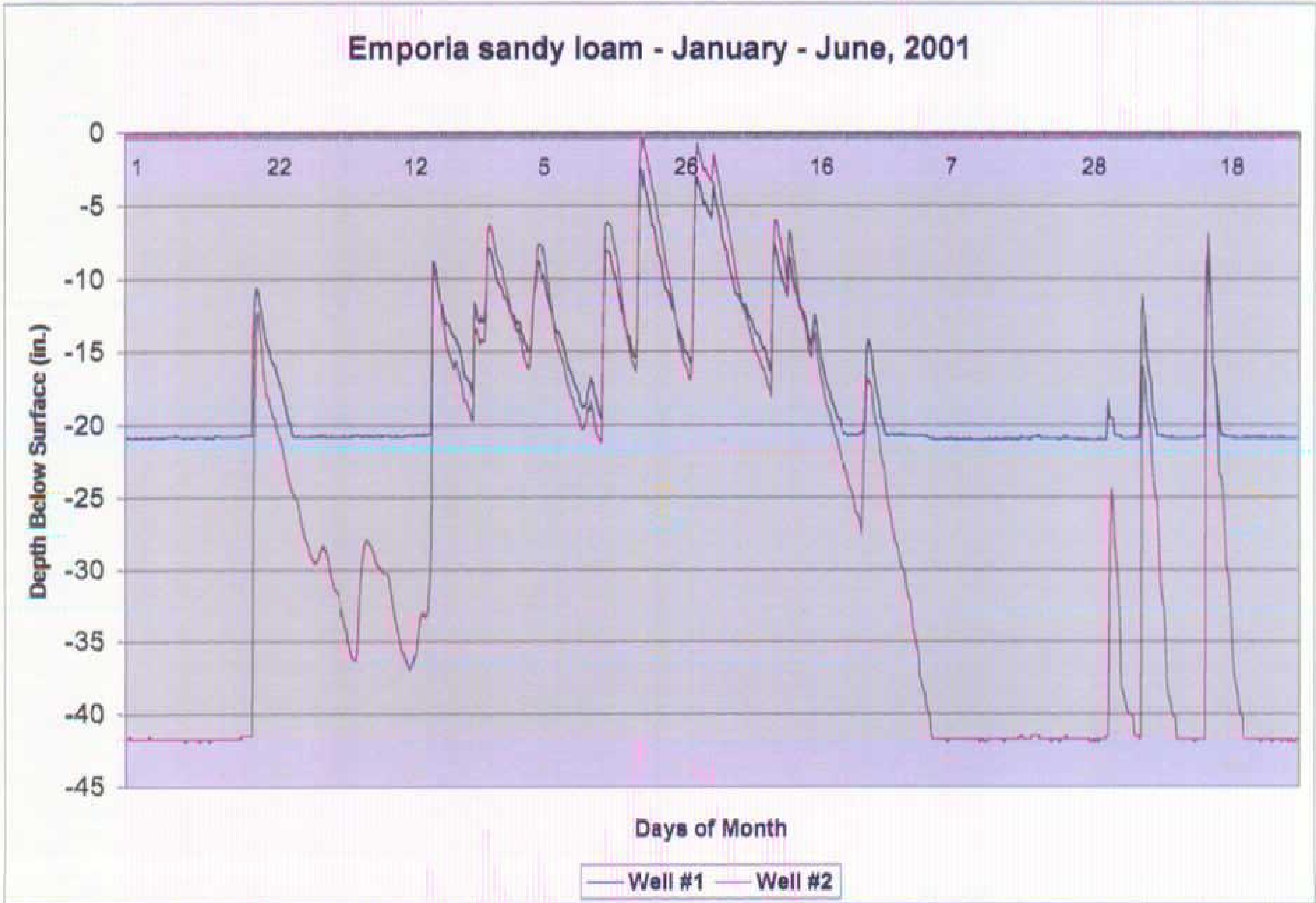
Emporia sandy loam - November - December,1999
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
Depth Below Surface (in.)
19
23
28
3
8
13
18
23
28
Days of Month
Well #1
Well #2



Emporia sandy loam - January - June, 2000
Depth Below Surface (in.)
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
1
22
12
4
25
15
6
27
17
Days of Month
Well #1
Well #2



Emporia sandy loam - July - December, 2000
Depth Below Surface (in.)
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
1 8 15 22 31 7 14 21 28 4 11 18 25 2 9 16 23 30 6 13 20 27 1 8 15 22 29
Days of Month
Well #1
Well #2


Emporia sandy loam - January - June, 2001
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
Depth Below Surface (in.)
1
22
12
5
26
16
7
28
18
Days of Month
Well #1
Well #2

SOIL EVALUATED: Faceville fine sandy loam

LOCATION:

The study site is in eastern Spotsylvania County, Virginia. Refer to the accompanying portion of the U.S. Geological Survey topographic map for the general topography and landforms. The accompanying site sketch shows the location of the automated data logger and two manual monitoring wells on the wooded and undeveloped property.

RATIONALE FOR SITE SELECTION:

The site was chosen because it is wooded and undisturbed. Also, a previous soil and site evaluation for a septic system drainfield by the Spotsylvania County Health Department had indicated that the general soil area potentially had some problems with .seasonal and periodic soil wetness. The site was ideal for the watertable study because several open backhoe pits on the property allowed for detailed observation of the soil profiles. The pits also allowed for a quick, visual check during each site visit to see if the backhoe pits were holding free groundwater. The Faceville and Emporia soils are widespread throughout the Coastal Plain province.

SOIL AND SITE INFORMATION:

The soils at this site formed in medium and fine textured, stratified, unconsolidated coaStal plain sediments. The Faceville soil is well drained, moderately permeable, and is classified as a fine, kaolinitic, thermic Typic Kanhapludult. The subsoil (Bt horizons) are yellowish red and red and have textures of clay loam, sandy clay, or clay.

The Soil Survey of Spots¥1vania County, Viminia (J.H. Elder, Jr., 1985) has the general study area soil mapped as Faceville and Varina complex. (A soil complex is mapped when the soils are so intermingled it is impractical to separate them at the mapping scale. In soil .mapping and classification, Varina soils are separated from other surrounding soils because of their plinthite content. Plinthite is a hard nodule of iron concentration. However, based on the backhoe pits and additional auger borings at the study site, the soils are more a complex of Faceville and Emporia soils. The Emporia soil is widespread and one of the most abundant soils in the upper Coastal Plain of Virginia. The Emporia soil is well drained and has moderately slow or slow permeability in the mid and lower Bt horizons. The Emporia soil commonly has a perched watertable during winter and spring.

A detailed soil profile description was made at the site using a backhoe pit and is included in this report. When compared to the official soil series description for the Faceville soil (refer to the Appendix), the soil at the study site generally is within the range of characteristics for the Faceville soil. This means the soil' is typical or representative of Faceville soils.

The Faceville soil is generally suitable for a septic system drainfleld. The clayey textures in the Bt horizons necessitate installing a large drainfield to compensate for potential slow permeability.

CLIMATIC DATA FOR THE SITE:

The Faceville study site is about 10 miles from Fredericksburg, Virginia. Weather data from the Fredericksburg' Sewage Plant (1999, 2000, and 2001) and the Fredericksburg National Park (29-year average) were used to provide yearly and monthly precipitation figures for the study site. The precipitation comparison graph for Spotsylvania County shows how each months precipitation total compares to the monthly 29-year averages (1961-1990).

During the November-December 1999-study period, precipitation was below normal. In fact, precipitation was only about 62% of the long-term average for the two month span. Also, many Parts of Virginia were experiencing severe drought conditions during 1999. With these dry conditions, it would be expected that watertable levels in the soils would be Iow or absent.

During the January-June 2000 study period, total precipitation was about 5 inches above the 29-year average of 20.05 inches. In June, rain totaled 9.74 inches, almost 3 times the 29-year average for that month.

During the July-December 2000 study period, total precipitation was about 3 inches above the 29-year average of 20.8 inches. Of note, only 0.05 inches of rain was recorded for October. This dry month anomaly only serves to emphasize how remarkably well annual precipitation is distributed in Virginia.

For the final study period from January-May 2001 (Faceville monitoring ended on 5-25-01), total precipitation was only about 2 inches less than the 29-year average, of 16.68 inches.

For the general study period beginning November 1999 and ending May 2001, total .- precipitation was about normal as compared to the 29-year average. The major exceptions were the relatively dry conditions near the end of 1999, and the months of June, July, and September in 2000 when a total of 26.85 inches of rain was recorded as opposed to the 29-year average for these months of 10.68 inches.

Results:

An automated (WL-40) data logger, a 24-inch manual, and a 60-inch manual well were installed in the Faceville soils. The data logger was about 100 feet from the two manual wells, which were about 10 feet apart. All wells were on the same gently sloping sideslope and all had the same vegetative cover consisting of Virginia pine with thick hardwood understory. Continuous automated data collection began on November 18, 1999. The manual wells were read only when visiting the site to download data from the data logger. The manual wells were not intended to gather watertable data on a frequent basis, instead, they were used mostly as a check to see how well the data logger and manual wells corresponded during download site visits.

All watertable monitoring wells and backhoe pits remained dry during the November 1999 to May 2001 study period. This is somewhat inexplicable, since the general site was a complex of Faceville and Emporia soils. Though both are well drained, Emporia commonly has a perched watertable during winter and spdng. In addition, most of the soil profiles evaluated over the general site have chroma 3 and 4 mottles in the upper Bt horizons, which in the Coastal Plain generally indicates some degree of soil wetness. The gently sloping sideslope where the wells were located transitions into a nearly level, upland fiat that would be expected to have soils with some wetness features.

CONCLUSIONS:

This particular Faceville soil site is much better drained than the soil features and properties indicate. The gently sloping sideslope landform on which the wells are located may allow for sufficient surface and subsurface lateral water movement, resulting in no watertable levels recorded during the study period.

NOTE: Because the monitoring wells were all dry during the study pedod, the watertable hydrograph and data tables are not included for the Faceville soil in this report.

FaceVille fine sandy loam

Soil Profile for Well # 1: (WL-40); 24-inch Manual Well; 60-inch Manual Well

A--0 to 1 inch; very dark grayish brown (10YR 3/2) and dark brown (10YR 3/3) fine sandy loam; moderate fine granular structure; very friable, non sticky, non plastic; 0 to 2% quartz gravel; common fine, medium, and coarse roots; clear wavy boundary.

E--1 to 10 inches; yellowish brown (10YR 5/4) heavy fine sandy loam; common fine and medium light yellowish brown (10YR 6~4) mottles; weak fine and medium subangular blocky structure; friable, non .sticky, non plastic; common fine, medium, and coarse roots; 0 to 2% quartz gravel; clear wavy boundary.

Bt1--10 to 16 inches; yellowish brown (10YR 5~4, 5/6) light clay loam; common medium and coarse light yellowish brown (10YR 6/4) mottles; weak coarse subangular blocky structure parting to weak fine and medium subangular blocky structure; firm, slightly sticky, slightly plastic; common fine, medium, and coarse roots; 0 to 2% quartz gravel; clear wavy boundary.

Bt2--16 to 22 inches; strong brown (7.5YR 4/6) heavy clay loam; common medium and coarse yellowish brown (10YR 5/4) mottles; weak fine, medium, and coarse subangular blocky structure; slightly firm, sticky, plastic; few fine, medium, and coarse roots; 1 to 5% quartz gravel; clear wavy boundary.

Bt3--22 to 28 inches; yellowish red (5YR 4/6) heavy clay loam; many medium and coarse light yellowish brown (10YR 6/4) and yellowish brown (10YR 5/4) mottles; weak thick platy parting to weak medium and coarse subangular blocky structure; firm, sticky, 'plastic; few fine, medium, and coarse roots; 2 to 5% quartz gravel; clear wavy boundary.

Bt4--28 to 38 inches; red (2.5YR 4/6) clay loam; common medium and coarse yellowish brown (10YR 5~4) mottles; common medium strong brown (7.5YR 4/6) ped coatings; weak thick platy parting to weak medium and coarse subangular blocky structure; firm, sticky, slightly plastic; few fine roots; 2 to 10% quartz gravel; clear wavy boundary.

2Bt5--38 to 62 inches; (auger description) red (2.5YR 4/6) light clay loam; many medium and coarse strong brown (7.5YR 4/6) ped coatings; weak thick platy parting to weak coarse subangular blocky structure; firm, sticky, slightly plastic; 2 to 5% quartz gravel; clear wavy boundary.

2BCt--62 to 75 inches; (auger description) mottled red (2.5YR 4/6), olive yellow (2.5Y 6~8), and strong brown (7.5YR 4/6) light clay loam; massive parting to weak platy and weak subangular blocky structure; firm, slightly sticky, slightly plastic; 2 to 5% quartz gravel.

Remarks: Profile described from a backhoe pit t° 38 inches and an auger boring from 38 to 75 inches. Landform is a gently sloping sideslope (2 to 7% slopes).

Spotsylvania County Water Table Monitoring Sites
on Hacketts Cliff Road

not to scale

Woods and
Thick. Understory

Faceville Soil
Well # 1
40 inch datalogger

Faceville Soil
Well # 2
24 inch manual well ~= 154' Approx.
(~.....20,....(~,_~oprox. 100'

Faceville Soil
Well # 3
60 inch manual well .

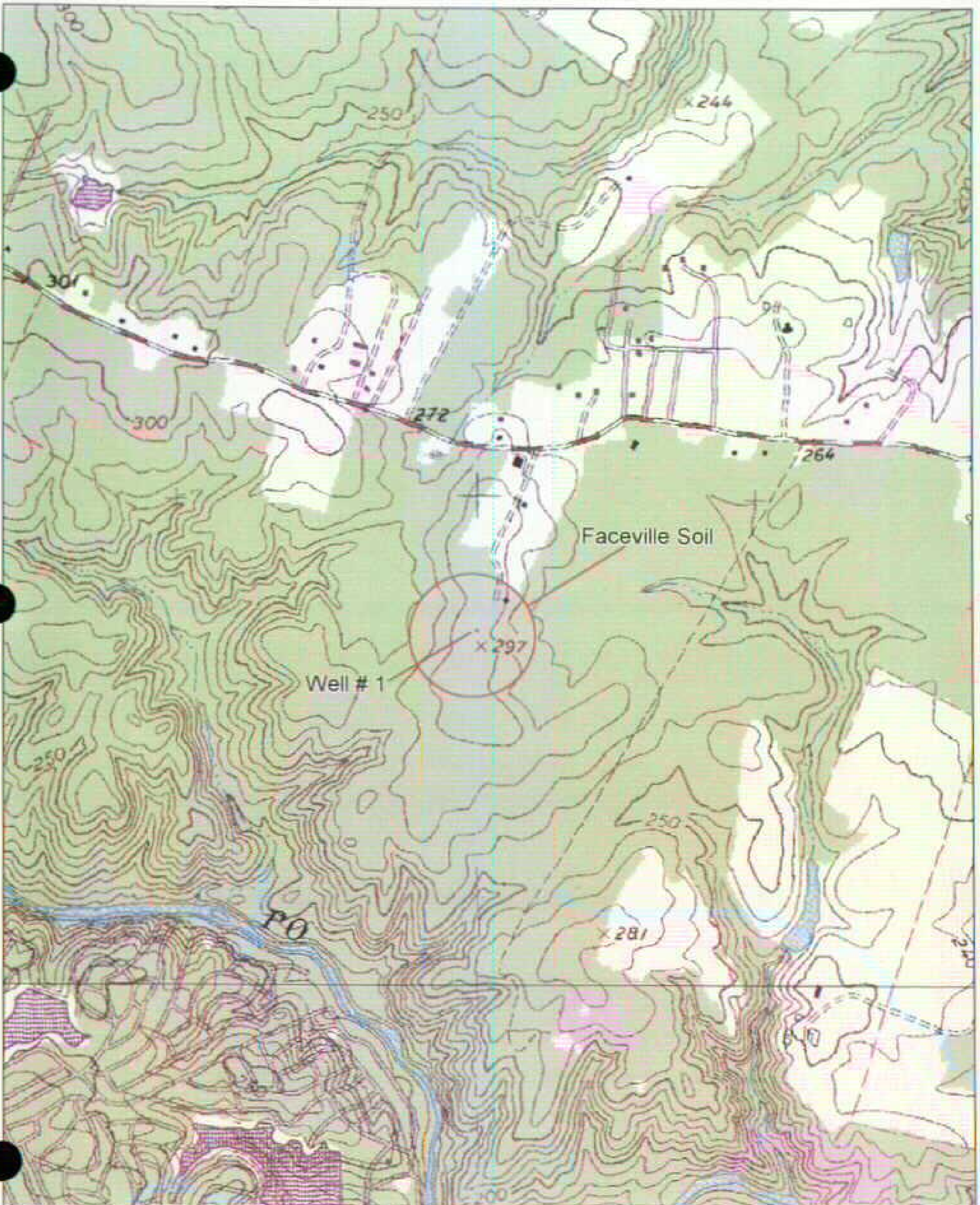
Approx. 156'

Woods and
Thick Under~tor~

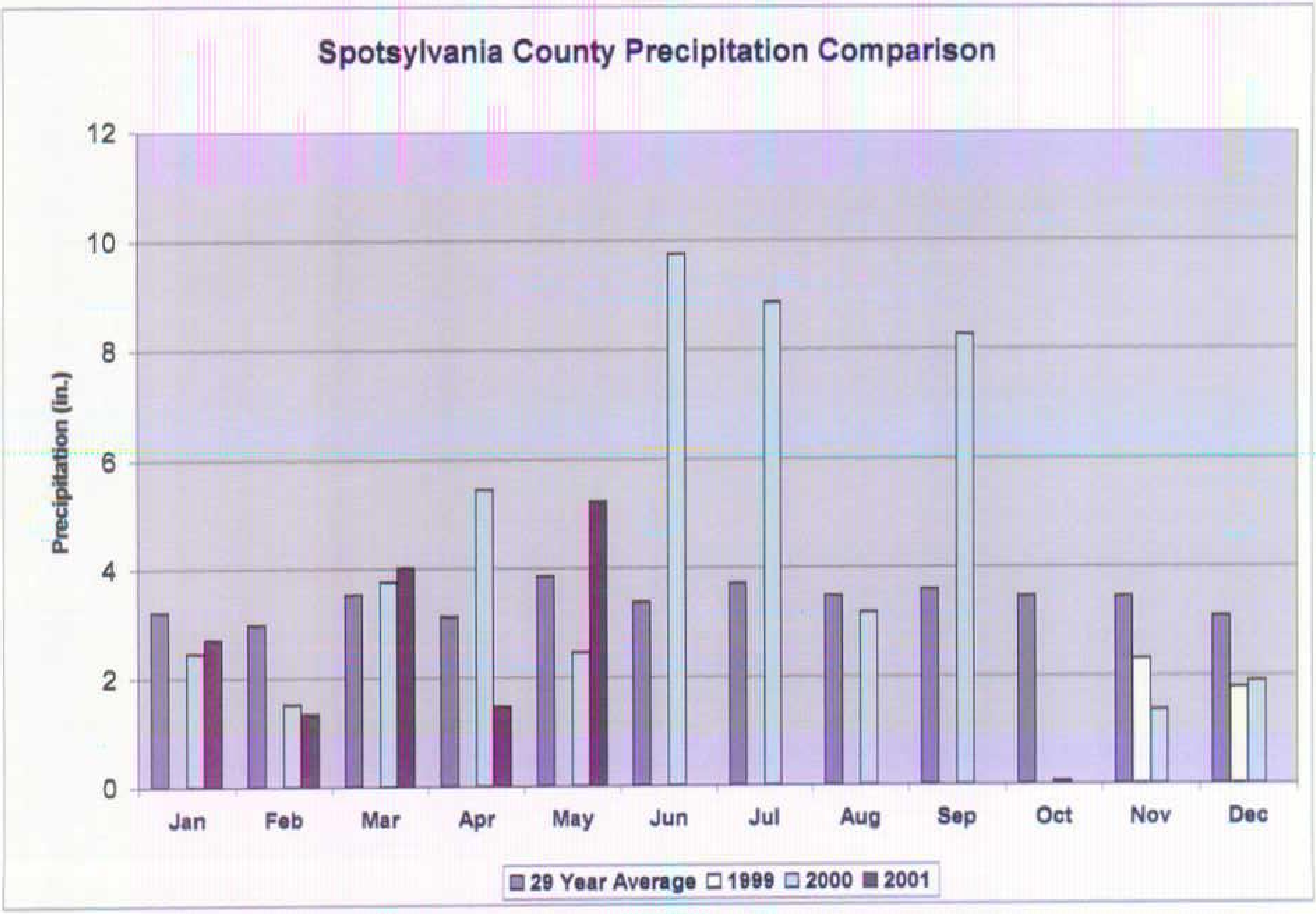
~ Woods and
I
I Thick Understory
I
I
I

Hackett~ Cliff Road (dirt road)

Wooded



500 ft Scale: 1 : 12,800 Detail: 14-0 Datum: WGS84


Spotsylvania County Precipitation Comparison
Precipitation (in.)
0
2
4
6
8
10
12
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
29 Year Average
1999
2000
2001

SOIL EVALUATED: Groseclose silt loam

LOCATION:

This research site was located in the central portion of Tazewell County, Virginia. Refer to the accompanying portion of the U.S. Geologic Survey Tiptop topographic map for the general character of the area and the location of an automated WL-40 data logger well on the farmland.

RATIONALE FOR SITE SELECTION:

There were several reasons for selecting this site. First, the type of soil at the site, Groseclose, represents a major soil type located over large areas in the Ridge and Valley Physiographic Province. To study it would provide valuable information that could apply to numerous sites considered for onsite septic systems. Second, the Groseclose soil meets Virginia criteria allowing for installation of a conventional gravity drainfield, and drainfields in this soil usuallywork properly on a year-round basis for many years. During a training session at this site one of my peers suggested the site was too wet for a drainfield to work properly. This concept was put forth due to the manganese stains and concretions present in the soil. And last, to check water movement in small intermittent drainageways.

SOIL AND SITE INFORMATION':.'

The soil at this site form from weathered limestone, siltstone, shale and sandstone of the Ridge and Valley Physiographic Province. There was a long, sloping hillside that lies upslope of the site. The site was on the lower sideslope, along the edge of a small drainway. The Well was in a small area of weeds while the majority of the upslope area was farmed in a corn-small grain crop rotation.

Currently there is no published soil survey of Tazewell County showing the mapping unit for the area or the agricultural use of the area.

A soil profile description was made at the site and is included. When compared to the official soil series description for the Groseclose series (refer to the Appendix), the soil at this site falls within the range of characteristics. That means the soil was typical or representative of Groseclose soils.

The soil was suitable for a conventional gravity drainfield over much of the training site. The area within the drainway was excluded because of the landscape position it occupied. When augered by Environmental Health

Specialists (EHS) manganese was observed and a statement made that it was to be considered a soil characteristic that signified wetness.

CLIMATIC DATA FOR THE SITE:

The site was 4 to 5 miles from the weather station in Burkes Garden, where official NOAA weather data were collected, so precipitation data from the station was used to evaluate rainfall during the study period. The precipitation comparison graph shows how rainfall totals each month compares to the monthly 29-year averages (1961-1990).

It is apparent that for the October-December 1999 period, precipitation was well below normal. In fact, rainfall was 64 % of the long-term average for the three month span. Therefore, the water table levels at the site would be expected to be deeper than during a fall with normal precipitation.

For the period January-June 2000, total precipitation was only 0.6 inches above the 29-year average. That means that the water table levels would be expected to be representative of normal conditions at the site.

For the period July-December 2000, monthly rainfall was .1 inch above the 29-year average. It is noteworthy that only 0.3 inch of rain was recorded for the entire month of October 2000, making it the driest October since data collection began in Burkes Garden. The October-December 2000 period was dry. In fact, rainfall was only 40 % of the long-term average for that 3 month span. That dry fall situation was very similar to moisture conditions noted for November-December 1999. Therefore, the water' table levels at the site would be expected to be shallower than during a fall with normal precipitation levels.

For the period January 2001, monthly rainfall was one inch above normal. Therefore, the water table levels at the site would be expected to be rising during January 2001.

Except for a few exceptional wet months the overall precipitation situation was one of below normal to near drought conditions. It should be noted that the original project completion date was extended due to severe drought conditions in most of the state during 1999. Fall of 2000 was similar to the Fall of 1999 being below normal. Therefore, only the January-December 2000 period had normal precipitation, while the rest of the study period had significantly below normal rainfall or was in the normally dry fall period.

RESULTS:

An automated data logger was installed ten feet from the center of the drainageway on December 7, 1999. The well was installed in the same soil, on the same landscape position, and at near the same topographic elevation, as our soil borings during the training module. Due to operator error, the automated well was not programmed properly and was reprogrammed within the week. The battery supplied with the data logger failed quicker than thought possible. The collection of water table data did not commence until February 4, 2000 when a new battery was installed and the data logger reprogrammed. There was continuous data collection from the starting date until January 23, 2001.

The Groseclose soil at this site had only a few pinkish gray (7.5YR 7/2) parent material mottles below 40 inches in the Bt4 horizon, making it a well-drained soil. The reddish yellow (7.5YR 6/8) mottles (or iron accumulations) were also present in the Bt4 horizon. It would be assumed that the seasonal water table would be below 66 inches, while there might be brief periods where it would spike or rise above that depth. These soils normally do not exhibit a water table within 5-feet of the surface. On this landscape position and to the described soil depth the manganese was used as the only wetness indicator.

The Fall of 1999 was dry and a review of the reading points for that period confirms that information. The list of reading points from December 1999 to February 2000 lists all readings between 41.3 and 41.4 inches. The water table hydrograph of February-June 2000 indicates the presence of free water in the soil at a depth of 39.8-41.4 inches for February and March of that period. The graph appears to indicate water readings above the 41.4-inch level. The VVL-40 data logger records readings to a depth of 40 inches by design. By telephone conversations with the staff of Remote Data Systems, Inc., I have learned there will often be a 1 to 2 inch accumulation of soil material in the bottom of the data logger housing. This soil material will often hold moisture and hence give a false positive reading. Using the formula ("Countir') for February - June 2000, water was present 1 day in the 36.1 to 39.7 depth range.

The July-December 2000 hydrograph shows the lowest dry level of 41.4 inches. The wettest or highest point the water table attained was 39.4 inches during the six-month period. The July-December Groundwater Data Table shows the surface of the free water being in the 36.1-39.5 inch zone for 9 days. There were 297 readings (readings divided by 4 equal's days) or 74 days where the surface of the free water level was recorded between 39.6 and 41.3 inches. There were 439 dry readings recorded between 41.3 and 42 inches. The 439 readings convert to 109 days where the data logger readings recorded a dry hole.

Readings between 39.5 and 42 inches correspond to the depth where mottles occur. However, no relationship can be drawn considering the presence of manganese. In this profile manganese began appearing at nine inches and continues to the bottom of the profile or 66 inches. The data logger is recording the surface of the free water in the Bt4 horizon. But the recordings are in the lower inch of the data logger's capabilities.

CONCLUSIONS:

This site had precipitation levels near normal for the majority of the study period. In spite of normal moisture periods, there was very little free water present for significant periods of time during the winter and spring. In addition, the depth to free water was much deeper than where manganese stains or concretions were observed in the soil. Once the water table rose in the soil, it stayed between the 36.1 to 39.5 inch depth range for 37 readings. All 37 readings were below 39.4 inches. These are not consecutive readings but indicate a recorded reading at different six-hour intervals. For the entire study period the data logger has indicated the Water level to be within an inch of the bottom for an extended period of time.

For approximately 699 readings the water level is recorded between 39.6 and 42 inches. The WL-40 records to 40 inches by design, yet here are 699 readings within 0.4 tenths of an inch of the design capacity. Also considering the chance of the lower inch or two of the data logger housing containing sediment which may hold moisture possibly causing false readings, not much significance can be attributed to the readings. Part of the moisture may also be considered to come from condensation on the inside walls of the data logger dripping or running to the bottom of the housing unit.

No free water level readings were ever recorded in the upper Bt horizons. Manganese was distributed throughout the profile from 9 to 66 inches. During the 14-month period all readings were lower than 39.4 inches! No spikes or sharp rises were noted on the hydrographs. The data logger is very sensitive and did record many 01-inch changes during the period. Soil water does not move up and down in 0.1-inch increments on a daily basis for long periods of time. Therefore these measurements are questionable to use to make any definitive statements. The frequent moisture level changes may be from condensation or moisture held in the soil accumulated in the bottom of the screen.

The hydrograph for the month of January 2001 shows the same problem as the other study periods except the graph is for one month only. With only a month the graph is enlarged more showing the small sharp rises and falls with a total span of 0.4 inch more clearly. During the 23-day period there were 92 readings taken by the data logger. All 92 readings were within 0.4 inch spacing. Even with the unit showing groat sensitivity no statements should be made as to the relationship between the water table levels and manganese at depths near 40 inches in this well.

Manganese as a moisture clue in soil and site evaluation should be altered to "soft manganese concretions or many manganese stains and or concretions" being required instead of manganese alone. "Few" manganese stains or concretions appear in nearly all-upland soils in central through western Virginia. To simply refer to any manganese as wetness and use as a reason for rejection eliminates greater than 60% to 70% (my estimate) of the area mentioned. Manganese as a morphological clue needs additional study and to be redefined if it is to be used as a limiting factor.

If the 36 to 42 inch depth range is crucial for a study then a WL-80 data logger should be incorporated to remove these observed problems from being a possible factor. On sloping sites in the Piedmont, Blue Ridge, Limestone Valley and Cumberland Plateau areas additional soil depth is required by the VDH Regulations for the installation of onsite systems. Often the required soil depths would be at or close to the 40-inch depth. It would be this type of situation that a WL-80 should be required instead of a WL-40 that might give questionable results.

The results of the study strongly suggest that a manual well should be installed as a cross check with the data logger. Checking the moisture levels in a manual well probably would have solved the questionable measurements made by the data logger.

A battery checker, such as Radio Shack's LCD Digital Multimeter, should be used during each monthly or bimonthly site visit to download data from the wells. While the Remote Data Systems, Inc., advertises a year as the life span of a battery, the well at this site wore out batteries in 30 to 60 days. Without frequent checking of the battery strength, data would be lost during a study.

There were no soil morphologic features that could be related to the presence of water in the soil for the number of days observed. In other words, there was no clue that this soil was wet at 39 to 40 inch depths. Under normal precipitation, it would be expected that the seasonal water table would be in the Bt horizons for 'at least some period of time if manganese as a morphologic feature actually related to soil moisture.

· ,With the well located along the edge of the drainageway, water level readings in the well should have been numerous due to the effect of the drainageway. For this site no relationship was observed between soil morphologic features, data logger readings and landscape position.

The location of this site on a lower sideslope, with an upslope watershed, should have Contributed to the water levels in the soil. During the winter-spring periods when plants were dormant and the evapotranspiration rate was very Iow, moisture not held in the soil moved downslope towards this site. The data logger never recorded any water movement. No abrupt lowering of the water table was recorded when the plants began leafing-out in their growth cycle.

As was noted earlier, this soil exceeded the minimum state requirements for a conventional gravity drainfield, based on soil morphology. Moving several feet away from the drainageway eliminated the landscape position problem.

Groseclose loam

Profile for Well # 1 (WL40)

Ap--0 to 9 inches; dark brown (7.5YR 3/4) heaw loam, friable, slightly sticky, slightly plastic; abrupt smooth boundary.

Bt1--9 to 16 inches; strong brown (7.SYR 5/6) clay loam; weak fine and medium subangular blocky structure; slightly firm; slightly sticky and slightly plastic; few black manganese stains; 5 percent chert gravel; clear smooth boundary.

Bt2--16 to 32 inches; strong brown (7.5YR 5/6) clay; moderate medium and strong subangular blocky structure; firm, sticky and plastic; few black manganese stains; 5 percent chert gravel; clear wavy boundary.

Bt3--32 to 40 inches; yellowish red (5YR 5/8) heavy clay; moderate medium subangular blocky structure; firm, sticky and plastic; thin clay films on faces of peds; common manganese stains; 5 percent chert gravel; gradual weathered boundary.

Bt4--40 to 66 inches; strong brown (7.5YR 5/6), reddish yellow (7.5YR 6/8), Ipinkish gray (7.5YR 7/2) heavy clay; moderate coarse prisms parting to coarse subangular blocky structure, firm, sticky and plastic; clay films on sides of prisms; common manganese stains on sides of prisms; few to common manganese concretions present.

Remarks: This profile description taken from an auger hole in a weedy area below the edge of a cornfield. The well location was ten feet out of the midline of a small drainway.

Table I - - Groseclose silt loam Groundwater Data Table
December 1999 (24 Days)
Gratton, Data Logger Well # 1

Well # 1

Depth Range (in.)	Number of Days	Percent Time	Cumulative Days	Percent Cumulative Days
0-6	0	0	0	0
6.1-12	0	0	0	0
12.1-18	0	0	0	0
18.1-24	0	0	0	0
24.1-30	0	0	0	0
30.1-36	0	0	0	0
36.1.-40	0	0	0	0'
Dry	24	100	24	100

Number of Days column refers to the number of days the surface of the free water was present within the depth range.

Percentage of Time column refers to the percent of time the water was present within the depth range.

Cumulative Days column refers to the total number of days the water was present within the depth range.

Percentage of Cumulative Days refers to the percent of total time the water was present within the depth range.

DRY corresponds to the number of readings (converted to days) where the monitoring well recorded no water in the hole.

Days in the column headings corresponds to the number of data logger readings within a depth range divided by the number (normally 2, 4 or 8) of data logger readings per day.

Table 1 - - Groseclose silt loam Groundwater Data Table

February - June, 2000 (148 Days)

Gratton, Data Logger Well # 1

Well # 1

Depth Range (in.)	Number of Days	Percent Time	Cumulative Days	Percent Cumulative Days
0-6	0	0	0	0
6.1-12	0	0	0	0
12.1-18	0	0	0	0
18.1-24	0	0	0	0
24.1-30	0	0	0	0
30.1-36	0	0	0	0
36.1-39.7	1	1	1	1
Dry	147	99	147	99

Table 2 - - Groseclose silt loam Groundwater Data Table

July - December, 2000 (184 Days)

Gratton, Data Logger Well # 1

Well # 1

Depth Range (in.)	Number of Days	Percent Time	Cumulative Days	Percent Cumulative Days
0-6	0	0	0	0
6.1-12	0	0	0	0
12.1-18	0	0	0	0
18.1 °24	0	0	0	0
24.1-30	0	0	0	0
30.1-36	0	0	0	0
36.1-39.5	9	5	9	5
Dry	175	95	175	95

Number of Days column refers to the number of days the surface of the free water was present within the depth range.
Percentage of Time column refers to the percent of time the water was present within the depth range.
Cumulative Days column refers to the total number of days the water was present within the depth range.
Percentage of Cumulative Days refers to the percent of total time the water was present within the depth range.

DRY corresponds to the number of readings (converted to days) where the monitoring well recorded no water in the hole.
Days in the column headings corresponds to the number of data logger readings within a depth range divided by the number (normally 2, 4 or 8) of data logger readings per day.

Table I - - Groseclose silt loam Groundwater Data Table
January 2001 (23 Days)
Gratton, Data Logger Well # 1

Well # 1

Depth Range (in.)	Number of Days	Percent Time	Cumulative Days	Percent Cumulative Days
0-6	0	0	0	0
6.1-12	0	0	0	0
12.1-18	0	0	0	0
18.1-24	0	0	0	0
24.1-30	0	0	0	0
30.1-36'	0	0	0	0
36.1-39.3	0	0	0	0
Dry	23	100	23	100

Number of Days column refers to the number of days the surface of the free water was present within the depth range.

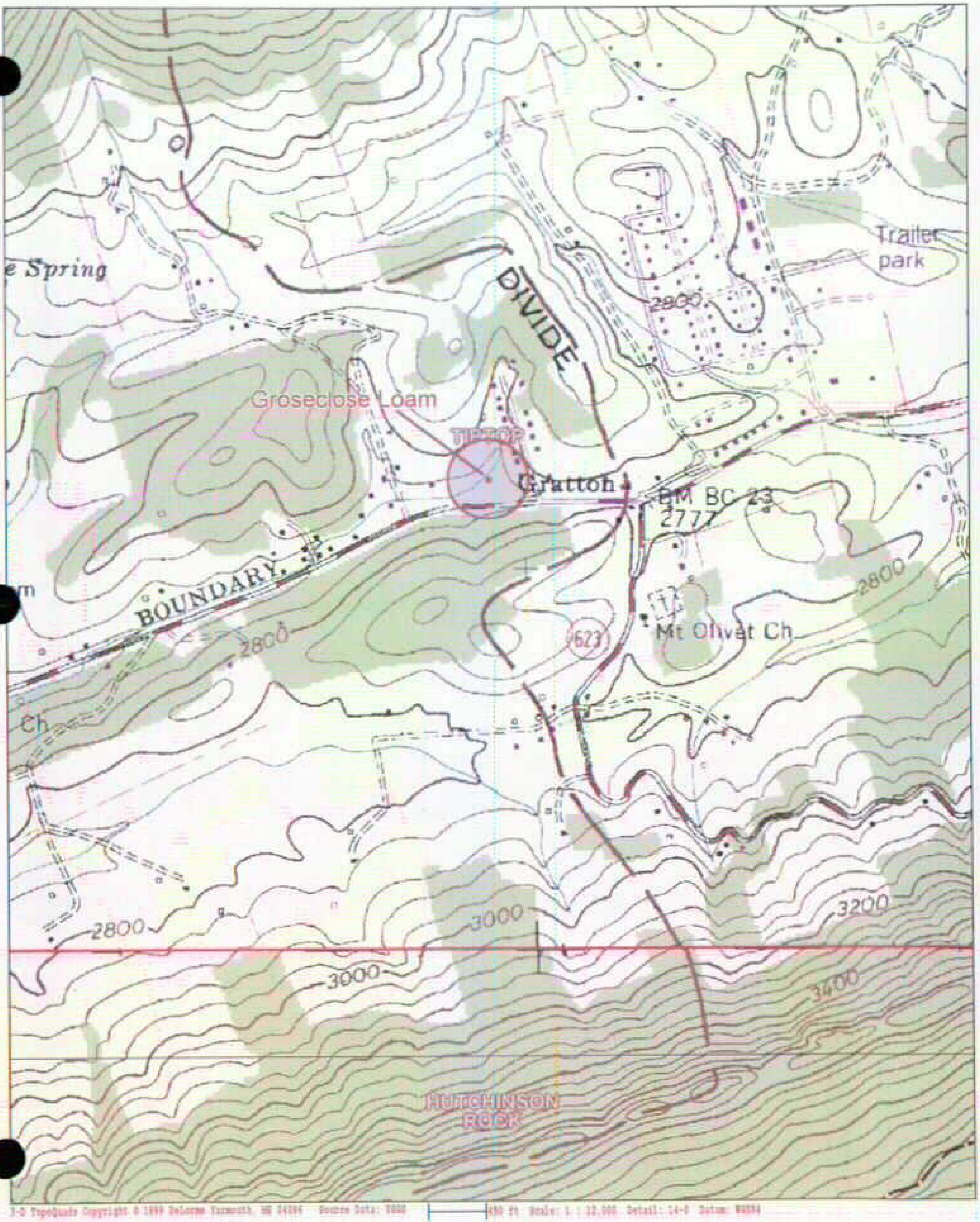
Percentage of Time column refers to the percent of time the water was present within the depth range.

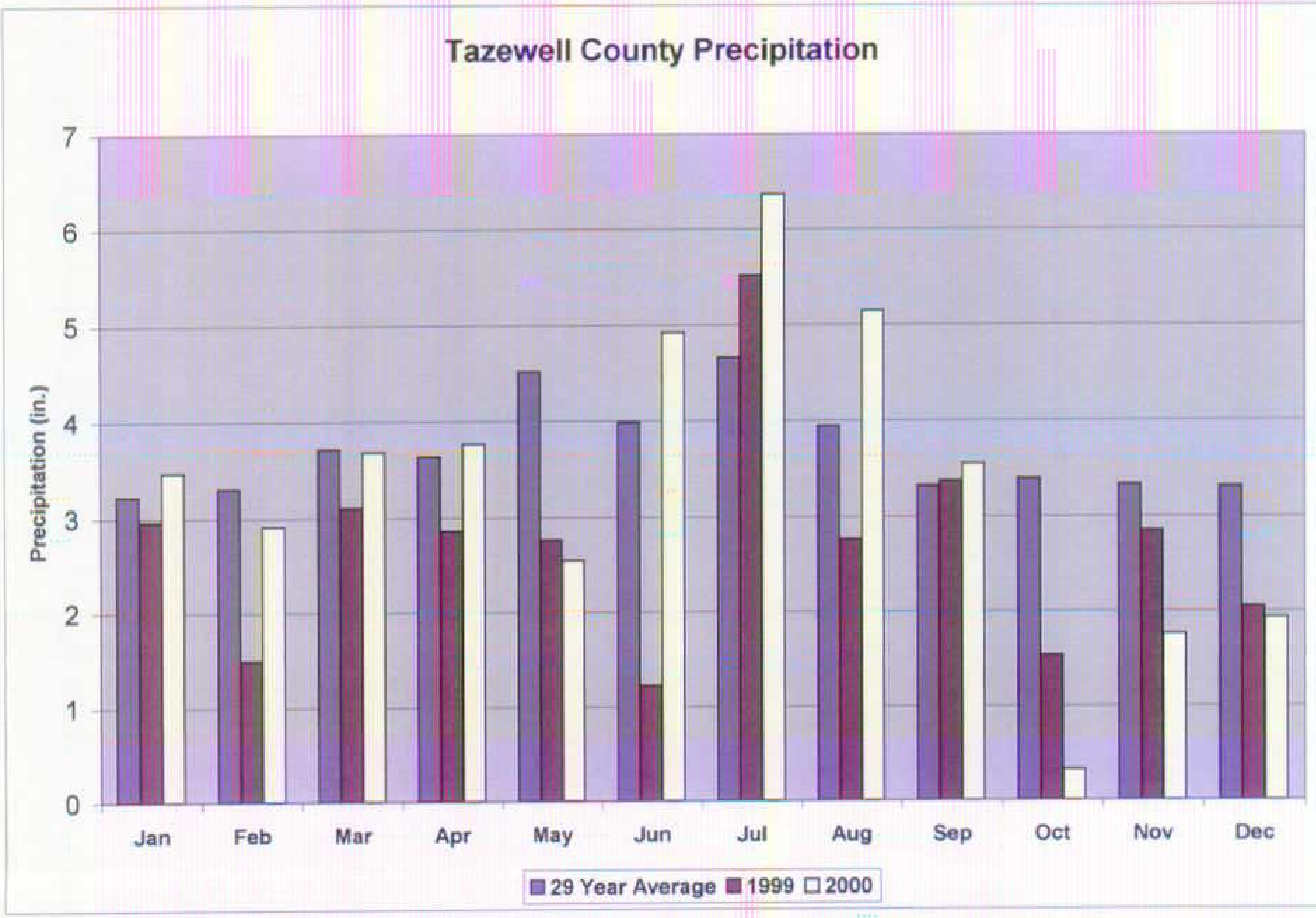
Cumulative Days column refers to the total number of days the water was present within the depth range.

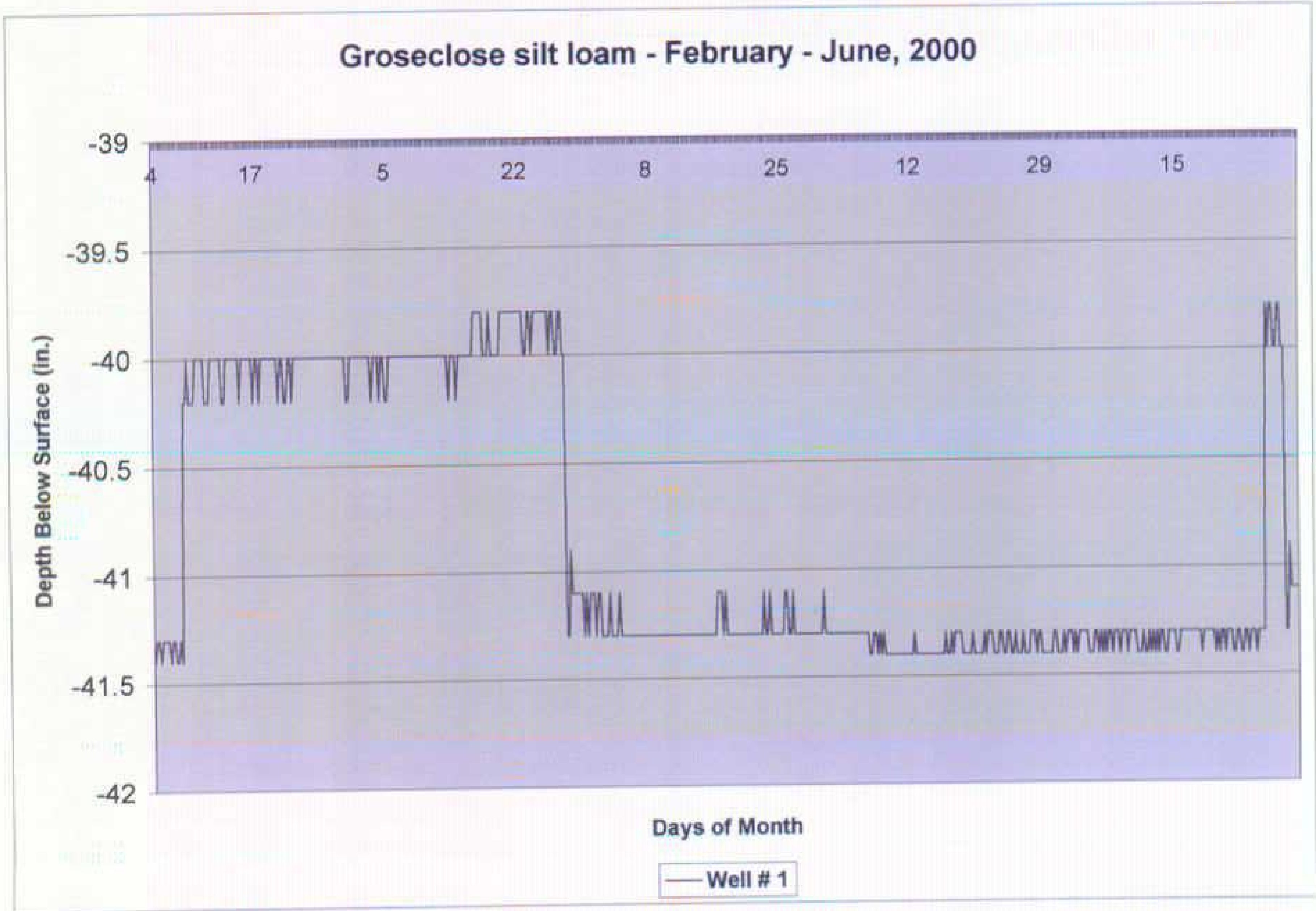
Percentage of Cumulative Days refers to the percent of total time the water was present within the depth range.

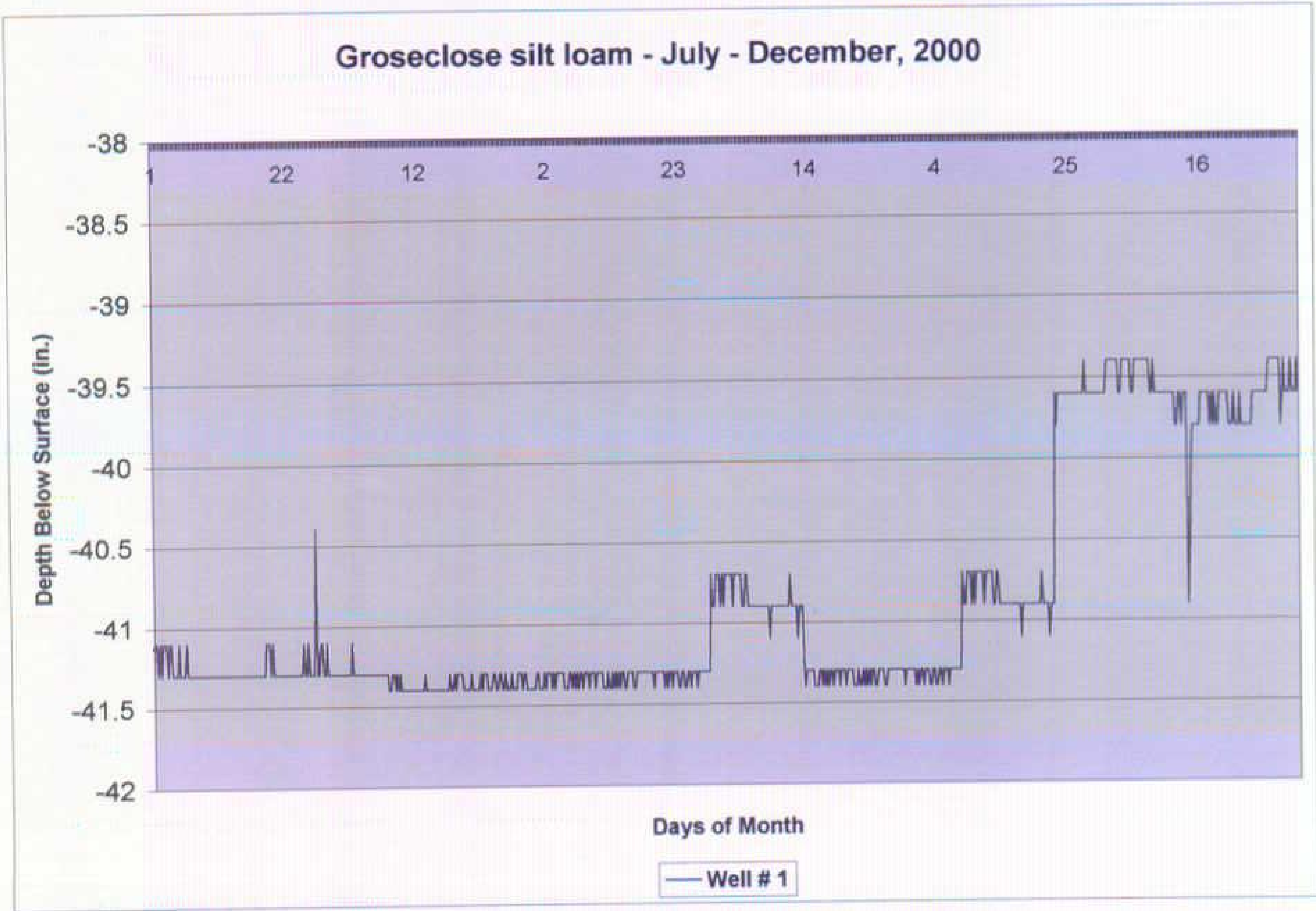
DRY corresponds to the number of readings (converted to days) where the monitoring well recorded no water in the hole.

Days in the column headings corresponds to the number of data logger readings within a depth range divided by the number (normally 2, 4 or 8) of data logger readings per day.


e Spring
DIVIDE
2800
Trailer park
Groseclose Loam
TIPTOP
Gratton
BM BC 23
2777
BOUNDARY
2800
Mt Olivet Ch
623
2800
Ch
2800
3000
3200
3000
3400
HUTCHINSON ROCK

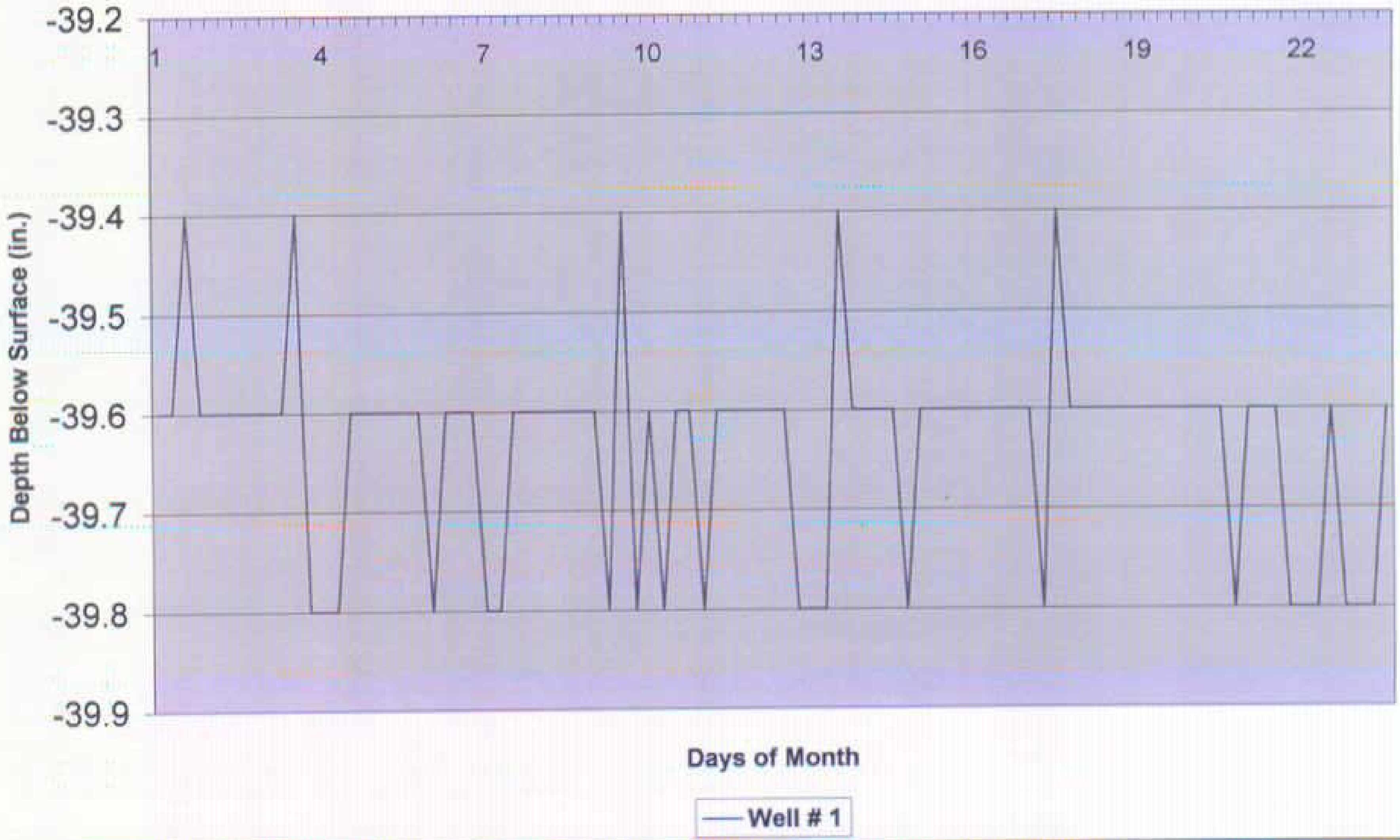

Tazewell County Precipitation
Precipitation (in.)
0
1
2
3
4
5
6
7
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
29 Year Average
1999
2000


Groseclose silt loam - February - June, 2000
Depth Below Surface (in.)
-39
-39.5
-40
-40.5
-41
-41.5
-42
4
17
5
22
8
25
12
29
15
Days of Month
Well # 1



Groseclose silt loam - July - December, 2000
-38
-38.5
-39
-39.5
-40
-40.5
-41
-41.5
-42
Depth Below Surface (in.)
1
22
12
2
23
14
4
25
16
Days of Month
Well # 1

Groseclose silt loam - January, 2001



SOIL EVALUATED: Jackland silt loam

LOCATION:

The study site is in the Triassic Basin within Piedmont province in northwest Pdnce William County, Virginia. Refer to the accompanying portion of the U.S. Geological Survey topographic map for the general topography and landforms. The accompanying site sketch shows the location of 'the automated data loggers in a open mature hardwood forest.

RATIONALE FOR SITE SELECTION:

The study site has Jackland soils that are not commonly used for conventional septic 'system drainfields because of very slow permeability and very high shrink-swell potential in the Bt horizon, soil wetness features, and shallow depths to weathered bedrock. The Jackland and related soils comprise thousands of vacant acres in Prince William, Fairfax, Loudoun, Fauquier, and Culpeper Counties in northern Virginia. And though the soils have several limitations for many different uses (including drainfields), the pressure to develop large tracts of land in Northern Virginia is intense and constant. Even when developed using central water and sewer, Jackland and related soils can present a host of problems, such as cracked house foundations, wet basements, and rupture of gas and utility lines. There is quite a bit of information on the physical features and properties of Jackland, but not much watertable information.

SOIL AND SITE INFORMATION:

The Jackland study site is in the Triassic basin of northern Virginia. Triassic basin soils dominantly are reddish in color and derived from parent rocks called redbeds. These sedimentary redbeds consist of reddish shale, siltstOne, fine-grained sandstone, and some conglomerate. Throughout the Triassic basin, igneous diabase dikes have. intruded the redbeds. The Jackland soil at the study site has developed in residuum weathered from one of these diabase dikes.

The Jackland study site is on a nearly level upland fiat or summit and slopes range from 0 to 2 percent. There is a upland drainageway about 25 to 40 feet from the monitoring wells, but it appears to have little affect on drainage of the soils because of the very slow permeability in the clayey Bt horizons. The site is in open mature hardwoods that are part of a large hardwood forest kept natural by the church organization that owns the property.

The Soil Survey of Prince William County, Virginia (John H. Elder, Jr., 1989) has the general soil area mapped (Sheet 6) as 56A: Waxpool silt loam, 0 to 2% slopes; 28B: Haymarket silt loam, 2 to 7% slopes; and 30B: Jackland silt loam, 2 to 7% slopes. Waxpool, Haymarket, and Jackland soils are closely related and all formed in residuum weathered from diabase, and in pla(~es basalt. According to the Prince William Soil Survey, the Jackland soil is very deep and moderately well drained and somewhat. poorly drained. It has very high shrink-swell potential and slow and very slow permeability in the clayey Bt horizons. The Jackland soil has a perched watertable I to 2 feet below the soil surface in winter and spring. It classifies as a fine, smectitic, mesic Aquic Hapludalf.

A detailed soil profile description was made at the site using a hand auger. 'When compared to the official soil series description for the Jackland soil (refer to the Appendix), the Jackland soil at the study site falls within the range of characteristics for the Jackland soil.

CLIMATIC DATA FOR THE STUDY SITE:

The Jackland study site is very near Lake Manassas, which is 10 to 12 miles southeast of The Plains. Weather data from The Plains (1999, 2000, 2001, and 29-year average) were used to provide yearly and monthly precipitation figures for the study site. The precipitation comparison graph for Fairfax and Prince William Counties shows how each monthly precipitation total compares to the monthly 29-year averages (1961-1990).

During the November-December 1999 study period, precipitation was below normal. Rainfall for the two months totaled 3.79 inches, which is 2.61 inches less than the 29-year average total of 6.40 inches. In addition, much of Virginia was having drought conditions during 1999 and 2000. However, the Jackland soil still had a perched watertable during the November-December 1999 study period.

During the January-June 2000 study period, total precipitation was 21.79 inches, which was 1.54 inches more than the 29-year average of 20.25 inches. June had the most precipitation at 6.55 inches followed by April with 4.72 inches. (June had the highest total for any month during the study period from November 1999 to May 2001.) February had the lowest precipitation, 1.98 inches, during the January-June 2000 study period.

During the July-December 2000 study period, total precipitation was 20.33 inches, which is 1.55 inches less than the 29-year average of 21.88 inches. August had the highest total precipitation at 6.24 inches, and October had the lowest total at 0.16 inches. (October 2000 was also the' driest month in many other parts of eastern and central Virginia. Only 0.05 inches were recorded in the Fredericksburg area during the study period.) The anomalous dry October only serves to emphasize how well annual precipitation is distributed in Virginia.

For the final study period form January-May 2001 (Jackland watertable monitoring ended May .25), total precipitation was 16.21 inches, nearly the same as the 29-year average of 16.49 inches. March had the highest total at 5.61 inches while. February had the lowest total at 1.64 inches.

For the entire study period beginning November 1999 and ending May 2001, total precipitation was about normal as compared to the 29-year average. The major deviations were the relatively dry months near the end of 1999, the relatively wetter than normal months of June and August in 2000, and the much drier than normal month of October 2000. All in all, the Jackland study site received sufficient precipitation to allow natural watertables to occur.

RESULTS:

An automated data logger (VVL-20, or Jackland 20) was installed at 20 inches and at 40 inches 0NL-40, or Jackland 40) in the Jackland soil. The wells were 56 feet apart and on the same nearly level upland fiat or summit. Both wells were in open mature hardwoods. The 20-inch data logger was designed to measure watertable levels in and above the plastic clayey Bt horizon, while the 40-inch data logger was designed to measure watertable levels in the diabase parent material and weathered bedrock. Continuous automated data collection began on November 17, 1999 and ended on May 25, 2001.

The~Jackland soil (called Iredell soil in the southern part of Virginia) is one of the few soils in Virginia that is rated by the National Cooperative Soil Survey as having very high shrink-swell potential in the clayey Bt horizons. This very high shrink-swell potential along with slow and very slow permeability in the Bt horizon should result in a seasonally perched watertable during winter and spring.

The watertable hydrograph for November-December 1999 shows that free water was in the Jackland 20 nearly all the time. The well was dry for two days in late November, but otherwise the watertable fluctuated mostly between 2 to 12 inches below the soil surface during the study period. The hydrograph even shows the watertable was about one inch above the soil surface for a day or so, but this is probably a quirk in the mechanics of the data logger. It does not appear the watertable was above the actual soil surface. Beginning in early December and ending in mid December, the Jackland 20 watertable had a repetitive pattern of rising sharply to a maximum in about a day,' and then taking 3 to 6 days to gradually drop back to 5 to 10 inches below the soil surface.

The watertable hydrograph for November-December 1999 in the Jackland 40 well shows a prominent series of peaks and valleys similar to the Jackland 20 well. In fact, beginning in December, the watertable level trends mirrored each other cloSely in both wells. In late November though, the watertable trends were diametrically opposed, with the Jackland 20 dropping to the dry level (watertable had dropped to about 21 inches or more below the soil surface) while the Jackland 40 had risen sharply to two inches below the soil surface. The Jackland 40 well was dry for several more days than the Jackland 20 well.

The Jackland 20 Groundwater Data Table (GWDT) for November-December 1999 indicates free water was in the ^ and EBt horizons for 14 cumulative days, or 32% of the time. Free water was in the Bt1 horizon for 32 cumulative days, or 73% of the time, while the Bt2 had free water for 42 cumulative days or 95% of the time. The depth range from 6.1 to 12 inches had the most days of free measured within it at 18. There were .only two dry days.

The Jackland 40 GWDT for November-December 1999 had free watertable in the ^ and EBt horizons for 6 cumulative days, or 14% of the time. The Bt1 horizon had free water for 15 days, or 34% of the time. The very plastic, very high shrink-swell Bt2 horizon had the surface of free water measured in it for 22 cumulative days, or 50% of the time. (Note: it must be remembered that when the surface of the watertable is in a higher horizon, it is assumed the lower horizon has free water in it also.) The Bt3 and CBt horizons had free water for 28 cumulative days, or 64% of the time. There Were 14 dry days in the well. It is surprising that the Jackland 40 well was able to "dry out" for this many days, since the Bt horizons have slow and very slow permeability, and the diabase parent'material is firm and dense. In other words, it was expected that once the Jackland soil got wet it would take a long time for the groundwater to move laterally or vertically in the soil. The Jackland 20 results for November-December 1999 appear to be a good example of this. The depth range from 6.1-12 inches had the most wet days recorded at 9.

The Jackland 20 hydrograph for January-June 2000 showed a watertable level that fluctuated mostly between 2 to 12 inches, below the soil surface, especially from February through April. Beginning in early May, the watertable level dropped to 15-18 inches below the soil surface. This drop corresponds to spring time leafing-out and increasing evapotranspiration. The highest recorded watertable was generally at the soil surface. June 2000 had 6.55 inches of rain, yet there was not an equivalent spike in the watertable for that month. The slow permeability in the Jackland Bt horizon may have a tempering and delayed effect in watertable response to a very wet time period.

The Jackland 40 hydrograph for January-June 2000 shows watertable trends cleady in tune with the Jackland 20.. The most surprising feature is that the Jackland 40 watertable levels actually rise to the same or higher levels than the Jackland 20. March watertable levels are a good example of this. Every peak and valley trend is present in both wells, with the Jackland 40 watertable rising above the Jackland 20 levels in most of the peaks. The general conclusion is that the Jackland 40 watertables are under the same hydrostatic pressures as the Jackland 20 levels. However, the wells were properly grouted with bentonite during installation so that the Jackland 20 well was monitoring the plastic Bt horizon and the Jackland 40 well was monitoring the firm, dense in place diabase parent material.

The Jackland 20 GWDT for January-June 2000 shows that free water was measured in the A and EBt horizons for 44 cumulative days, or 24% of the time; in the Bt1 horizon 98 days or 53% of the time; and in the plastic clay' Bt2 hodzon 151 days, or 83% of the time. There were 31 dry days when the watertable dropped below the monitoring level of about 20 inches. The highest number of days where the free water surface level was measured in a depth range was 54 in the 6.1-12 inch range.

The Jackland 40 GWDT for January-June 2000 shows that free water was in the A and EBt horizons for 23 cumulative days, or 12% of the time. The Bt2 (using the 12 to 24 inches depth range) had cumulative water for 66 days, or 36% of the time. The 40 inch monitoring well was dry for a total of 88 days, or 48% of the 182 day time span.

The hydrographs for the July-December 2000 Jackland 20 well and the Jackland 40 well again almost perfectly mirror each other, with the only difference being the respective depths of the watertable. The Jackland 20 well stayed wet for the entire 184 day period, with the level mostly staying between 15 to 19 inches below the soil surface. Watertable spikes above 15 inches occurred in July, August, and December. The August spike is the only one that roughly correlates with higher than average rainfall. August received 6.24 inches of rain in 2000 and the spike rose to about 13 inches below the soil surface. The Jackland 40 well stayed dry for most of the period, with only short spikes in July, August, September, and December. Again, only the August spike roughly correlates with relatively higher than normal rainfall for the month.

The Jackland 20 July-December 2000 GWDT shows that groundwater was not measured in the A and EBt horizons. However, the Bt1 and the Bt2 had free water in them for all 184 days. This long term wetness with little fluctuation fits the situation where the plastic clayey Bt horizons get wet and do not "dry out" for a long time.

The Jackland 40 July-December 2000 GWDT had a total of 148 days of dry readings, which was 80% of the 184-day span. And of the remaining 36 days in the time span, 21 to 36 days had free water between 30 to 40 inches below the soil surface. These long dry periods in the Jackland 40 parallel the wetness in the Jackland 20, only conversely. Whereas the slowly permeable Bt horizon eventually gets wet and stays wet in the Jackland 20 well, the firm and dense diabase parent material/rock in the Jackland 40 is dry and stays mostly dry. Accepting this model implies that the clayey Bt horizon is relatively unable to transmit groundwater to the underlying parent material horizons.

The Jackl~nd 20 and Jackland 40 hydrographs'for January-May 2001 are more of the same! They perfectly mirror the watertable trends, and in all the peaks the 40 inch data logger is essentially recording the same watertable levels as the 20 inch data logger. From mid January to mid April the watertable fluctuated in both wells at mostly 0 to 10 inches below the soil surface.

The Jackland 20 GWDT for January-May 2001 shows free was measured at some depth between 0 to 19 inches for all of the 145 day span. In other words, there were no dry days. Free water was in the A and EBt horizon for 47 cumulative days, or 32% of the time; in the Bt1 for 96 cumulative days, or 66% of the time; and in the plastic clayey Bt;?_ horizon for 145 cumulative days, or 100%. of the time. The "once wet stays wet" model for the slowly permeable clayey Bt horizon seems to be at work.

The Jackland 40 GWDT for January-May 2001 shows that free water was measured in the A and EBt horizon for 35 cumulative days, or 24% of the time; free water was in the Bt1 horizon for 91 cumulative days, or 63% of the time; and free water was in the Bt2 horizon for 94 days, or 65% of the time.

In the Number of Days column, it is shown that the depth range from 0-6 and 6.1-12 combined had water in them for a total of 91 days, which is 63% of the 145 day span. Dry days in the well were 44, or 30% of the span. If you consider the depth range wet only when the surface of free water is measured in any particular depth range, (and not cumulatively added together) the data table is showing that groundwater is dominantly perched between 0 to 12 inches below the soil surface. Following this logic, the depth ranges below 12 are essentially dry, with a total of only 5 days of free water surface measured from 12.1-36 inches. The depth range from 36.1-39.7 inches had only 5 days also. This logic roughly supports the idea that the plastic clayey Bt horizon is perching groundwater and is tightly holding the water in place. At the same time, the diabase parent material horizons and the depth ranges below 12 inches are relatively dry. However, if this approach is logical, the weak point is how does the diabase parent initially get wet, and how is it able to closely mirror the watertable peaks produced above and within the Bt horizons?

CONCLUSIONS:

The Jackland 20 well stayed wet most of the time dudng the study. The surface of free water was measured in some part of the soil between 0 to 19.5 inches below the soil surface for a total of 523 days, which is 94% of the 556 total days in the project. There were only 33 dry days recorded by the WL-20 data logger.

The bottom of the WL-20 data logger is anchored in the Jackland Bt2 horizon. Referring to the Jackland description at the study site, the Bt2. is from 12 to 23 inches belOw the soil surface and is olive brown with a heavy clay texture. This Bt2 horizon has pronounced plasticity, estimated very high shrink-swell potential, and estimated very slow permeability (less than 0.06 inches per hour; Prince William County Soil Survey). The horizon also has some grayish (2.5Y 4~2) streaks, many manganese stains, and a few manganese concretions. It is expected that the Jackland soil would have a pronounced perched watertable above and within the very plastic clayey Bt horizon. The Soil Survey indicates the Jackland soil has a seasonally perched watertable at 1 to 2 feet below the soil surface from December through April.

When data logger depth ranges are grouped together to roughly correspond with the horizon depths described for the Jackland soil, it can be seen that the A and EBt horizons (0-6 inches) had the surface of free water present for 105 days, or 19% of the 556 total days. The Bt1 horizon (6-12 inches) had the surface of free water measured in it for 128 days, or 23% of the total 556 days. The Bt2. horizon (12-24 inches) had the level of free water in it for 290 days, or 52% of the total 556 days.

The hydrographs for the Jackland 20 generally show quick spikes in the watertable, followed by relatively gradual drops in the watertable. The simple conclusion is that increments of groundwater can be "quickly added" to the perched watertable above the plastic Bt2 horizon, which causes rapid spikes. However, it takes several days for the watertable to appreciably drop, whether by vertical or lateral movement. The gradual drops are controlled by the very slow permeability in the plastic clayey Bt2 horizon.

The Jackland 40 well stayed dry a bare majority of the time. The surface of free water was measured in some part of the soil between 0 to 40 inches below the soil surface for a total of 261 days, or 47% of the 555 days in the study period. The free water surface was below 40 inches or dry for 294 days, or 53% of the time.

The bottom of the Jackland 40 well was anchored in the diabase parent material. Referring to the Jackland prOfile described at the study site, the C horizon is 34 to 45 inches below the soil surface and is mostly white diabase parent material with a few olive brown clay flows and common black manganese oxide stains and coatings. The parent.is firm and dense in place, and when wetted and worked thoroughly, it has a texture of gritty loam.

When data logger dePth ranges are grouped together to roughly correspond with the horizon depths described for the Jackland soil, it can be seen that the ^ and EBt horizons (0 to 6 inches) had the surface of free water measured in them for a total of 64 days, or 11% of the 555 day period. The Bt1 horizon (6 to 12 inches) had the surface of free water in it for 93 days, or 16% of the time. The Bt2 horizon (12-24 inches) had the surface of free water measured in it for 30 days, or 6% of the 555-day span. The Bt3 and CBt horizons (24 to 36 inches) had a free water surface measured for 45 days, or 9% of the 555 days. Dry days, when the watertable surface dropped below about 40 inches, totaled 294, or 53% of the time.

The Jackland 40 hydrographs show that watertable levels could spike very quickly and also drop very quickly. Generally, the Jackland 40 spikes dropped a little more quickly than the accompanying Jackland 20 spikes.

With a minor exception in the early part of the November-December 1999 study span, .. the hydrograph trends for Jackland 20 and Jackland 40 nearly always mirrored each other th¢oughout the entire study period. The January-May 2001 span is a good example of this. Every peak and valley in the Jackland 20 watertable table is matched in trend by the Jackland 40 watertable. And the hydrograph shows that the Jackland 40 watertable level rose in unison as high or higher than the Jackland 20 well. (The reason for this is open to speculation, since the Jackland 40 well was groUted with bentonite to only allow for monitoring of the parent material.) This feature was prominent in most of the study spans, though the July-December 2000 span only had two events where the Jackland 40 rose to the same height as the Jackland 20. (NOte: The July-December 2000 Jackland 20 had many days where the watertable level was between 17 to 20 inches below the soil surface. Ordinarily, when the line graph was relatively fiat for many days, it was assumed that the well was dry or going dry. The Jackland 20 was an exception .to this. Because of the very slow permeability and pronounced plasticity of the Bt2 horizon in which the Jackland 20 was anchored, the horizon could get wet and stay wet with only minor fluctuations.)

Overall, the watertable study showed that the very plastic, slowly permeable, clayey Bt horizon in the Jackland soil is the major controller and influence the on the shallow watertables. It has long been thought that the very plastic, clayey Bt horizons not only limit or prevent groundwater movement, but they also essentially do not "dry out", " unless there is an extended drought. Even then, the very fine soil pores in the smectitic clays (shrink-swell) are able to hold a certain amount of moisture.

The diabase parent material beneath some Jackland soils weathers to a gritty, sand-sized texture. These gritty textures are commonly called jack-sands and on first appearance look relatively permeable and perhaps suitable for a drainfield. When properly wetted and worked in the hands though, the gritty materials commonly break down to a finer texture. In essence, the jack-sands are the ground-up product of mostly firm and dense in place diabase parent materials. The diabase parent material weathers irregularly over an area, with relatively deep pockets mixed with shallow zones of firm, dense parent material and/or weathered bedrock (Cr horizons). This highly variable weathering over short distances is not conducive for siting a drainfield.

The Jackland soil has done nothing to recommend it for any kind of onsite wastewater treatment and disposal system, based on this watertable study. In fact, by virtue of having a perched watertable from 0 to 12 inches below the soil surface for a significant amount of time, the Jackland soil has essentially eliminated the possibility of using spray irrigation as a means of wastewater disposal/dispersal. Virginia's Sewage Handlinq and Disposal Regulations (2000) generally require that there be no soil wetness or restrictive permeability features from the soil surface to a depth of 12 inches,' if the site is to be used for spray irrigation.

'Jackland silt loam

Soil Profile for Well # 1' (WL-20 Data Logger)
Soil Profile for Well # 2:(WL-40 Data Logger)

A--0 to 2 inches; very dark grayish brown (10YR 3/2) silt loam; friable; slightly sticky, slightly plastic.

EBt--2 to 7 inches; very pale brown (10YR 7~3) and light olive brown (2.5Y 5~4) clay loam; firm; sticky, plastic.

Bt1--7 to 12 inches; light olive brown (2.5Y 5~6) clay; firm; sticky, plastic.

Bt2--12 to 23 inches; olive brown (2.5Y 4~4) heavy clay; few fine dark grayish brown (2.5Y 4~2)streaks; many fine and medium black (7.5YR 2~0) manganese stains, coatings, and few concretions; very firm; sticky, very plastic; very high shrink-swell potential; restrictive permeability.

Bt3--23 to 29 inches; light olive brown (2.5Y 5~6) gritty heavy clay loam; many fine whitish parent material flecks; common fine black (7.5YR 2~0) manganese oxide stains and coatings; very firm; sticky, plastic.

CBt--29 to 34 inches; light olive brown clay flows and white (10YR 8~2) diabase parent material; when wetted and worked thoroughly, soil materials texture to gritty heavy clay loam; very firm; sticky, plastic.

C--34 to 45 inches; white (10YR 8~2) diabase parent materials and a few light olive brown (2.5Y 5~6) clay flows; common black (7.5YR 2~0) manganese oxide stains and coatings; when wetted and worked thoroughly, soil materials texture to sticky, slightly plastic, gritty loam; soil materials firm in place.

CICr--45 to 58 inches; white (10YR 8~2) and light olive brown (2.5Y 5~6) diabase parent material that is very firm in place and generally grades to weathered bedrock; when wetted and worked thorOughly, soil materials texture to sticky, slightly plastic, gritty loam; common black (10YR 2/1) manganese oxide stains and coatings.

Remarks: Data loggers are 56 feet apart and are on the same nearly level upland fiat. Auger borings beside each data logger confirm that the profile described above is very typical for both well sites. Soils are a good fit in the Jackland soil series.

Table I - - Jackland silt loam Groundwater Data Table
November- December, 1999 (44 Days)
Camp Glenkirk - Data Logger # 1 (WL- 20)

Well # 1

Depth Range (in.)	Number of Days	Percent Time	Cumulative Days	Percent Cumulative Days
0 - 6	14	32	14	32
6.1-12	18	41	32	73
12.1-19.5	10	23	42	95
DRY	2	4	44	100
24.1-30	......			
30.1-36	....			
36.1_40	......			
DRY	......			

Table 2 - - Jackland silt loam Groundwater Data Table
January - June, 2000 (182 Days)
Camp Glenkirk - Data Logger Well # 1 (WL-20) ..
Well # 1
Percent

Depth Range (in.)	Number of Days	Percent Time	Cumulative Days	Cumulative Days
0 - 6	44	24	44	24
6.1 -12	54	30	98	53
12.1-18.1	53	, 29	151	83
DRY	31	17	182	100
24..1-30	....			
30.1-36	.....			
'36.1_40	....			
DRY	......			

Number of Days column refers to the number of days the surface of the free water was present within the depth range.
Percentage of Time column refers to the percent of time the water was present within the depth range.
Cumulative Days column refers to' the total number of days the water was present within the depth range.
Percentage of Cumulative Days refers to the percent of total time the water was present within the depth range.

DRY corresponds to the number of readings (converted to days) where the monitoring well recorded no water in the hole.
Days in the column headings corresponds to the number of data logger readings within a depth range divided by the number (normally 2, 4 or 8) of data logger readings per day.

Table 3 - - Jackland silt loam Groundwater Data Table
July - December, 2000 (184 Days)
Camp Glenkirk - Data Logger 1 (WL-20)
Well # 1

Depth Range (in.)	Number of Days	Percent Time	Cumulative Days	Percent Cumulative Days
0-6	0	0	0	0
6.1-12	6	3	6	3
12.-19.6	178	97	184	100
DRY	0	0	0	0

24.1-30	....
30.1-36	.....
36.1-40	....
DRY	....

Table 4 - - Jackland silt loam Groundwater Data Table
January - May, 2001 (145 Days)
Camp Glenkirk - Data Logger Well # 1 (WL-20)

Well # 1

Depth Range (in.)	Number of Days	Percent Time	Cumulative Days	Percent Cumulative Days
0 - 6	47	32	47	32
6.1-12	50	34	96	66
12.1-18.4	48	33	145	100
DRY	0	0	0	0
24.1-30	....			
30.1-36	......			
36.1-40	......			
DRY	......			

. Number of Days column refers to the number of days the surface of the free water was present within the depth range.
Percentage of Time column refers to the percent of time the water was present within the depth range.
Cumulative Days column refers to the total number of days the water was present within the depth range.
Percentage of Cumulative Days refers to the percent of total time the water was present within the depth range.

DRY corresponds to the number of readings (converted to days) where the monitoring well recorded no water in the hole.
Days in the column headings corresponds to the number of data logger readings within a depth range divided by the number (normally 2, 4 or 8) of data logger readings per day.

Table 5 - - Jackland silt loam Groundwater Data Table
November- December, 1999 (44 Days)
Camp Glenkirk - Data Logger # 2 (WL-40)
Well # 2

Depth Range (in.)	Number of Days	Percent Time	Cumulative Days	Percent Cumulative Days
0-6	6	14	6	14
6.1-12	9	21	15	34
12.1-18	4	9	19	43
18.1-24	3	7	22	50
24.1-30	2	4	24	55
30.1-36	4	9	28	64
36.1-39.6	2	4	30	68
DRY	14	32	44	100

Table 6 - - Jackland silt loam Groundwater Data Table
January - June, 2000 (182 Days)
Camp Glenkirk - Data Logger # 2 (WL- 40)

Well # 2

Depth Range (in.)	Number of Days	Percent Time	Cumulative Days	Percent Cumulative Days
0 - 6	23	12	23	12
6.1-12	27	15	50	27
12.1-18	7	4	58	32
18.1-24	9	5	66	36
24.1-30	12	7	78	43
30.1-36	9	5	87	48
36.1-39.7	7	4	94	52
DRY	88	48	182	100

Number of Days column refers to the number of days the surface of the free water was present within the depth range.
Percentage of Time column refers to the percent of time the water was present within the depth range.
Cumulative Days column refers to the total number of days the water was present within the depth range.
PerCentage of Cumulative Days refers to the percent of total time the water was present within the depth range.
DRY corresponds to the number of readings (converted to days) where the monitoring well recorded no water in the hole.

Days in the column headings corresponds to the number of data logger readings within a depth range divided by the number (normally 2, 4 or 8) of data logger readings per day.

Table 7 - - Jackland .silt loam Groundwater Data Table

July - December, 2000 (184 Days)

Camp Glenkirk - Data Logger # 2 (WL- 40)

Well # 2

Depth Range (in.)	Number of Days	Percent Time	Cumulative Days	Percent Cumulative Days
0-6	0	0	0	0
6.1-12	I	1	1	1
12.1-18	2	1	2	1
18.1-24	2	1	4	2
24.1-30	5	3	9	5
30.1-36	11	6	21	11
36.1-39.7	15	8	36	20
DRY	148	80	184	100

Table 8 Jackland silt loam Groundwater Data Table

January - May, 2001 (145 Days)

Camp Glenkirk - Data Logger # 2 (WL- 40)

Well # 2

Depth Range (in.)	Number of Days	Percent Time	Cumulative Days	Percent Cumulative Days
0 - 6	35	24	35	24
6.1-12	56	39	91	63
12.1-18	2	I	93	64
18.1-24	1	1	94	65
24.1-30	1	1	95	66
30.1-36	1	1	96	66
36.1-39.7	5	3	101	70
DRY	44	30	145	100

Number of Days column~ refers to the number of days the surface of the free water was present within the depth range.

Percentage of Time column refers to the percent of time the water was present within the depth range.

Cumulative Days column refers to the total number of days the water was present within the depth range.

Percentage of Cumulative Days refers to the p~rcent of total time the water was present within the depth range.

DRY corresponds to the number of readings (converted to days) where the monitoring well recorded no water in the hole.

Days in the column headings corresponds to the number of data logger readings within a depth range divided by the number (normally 2, 4 or 8) of data logger readings per day.

"Table 9 - Jackland 20 Well - Days Surface of Free Water Recorded in Depth Range ~556 Days)

Depth Range (in.)	Nov-Dec 99	Jan-Jun 00	Jul-Dec 00	Jan-May 01	Total Days	% Total Days
0 -6	14	44	0	47	105	19
6.1-12	18	54	6	50	128	23
12.1-19	10	54	178	48	290	52
DRY	2	31	0	0	33	6

24.1-30 ......
30.1-36 ....
36.1-40 ....
DRY ....

** For other soils in the study, this table is generally described in the narrative.

**Table 10 - J-ackland 40 Well - Days Surface of Free Water Recorded in Depth Range (555 Days)

Depth Ran~/e (in.)	Nov-Dec 99	Jan-Jun 00	Jul-Dec 00	Jan-May 01	Total. Days	% Total Days
0 - 6	6	23	0	35	64	11
6.1-12	9	27	1	56	93	16
12.1-18	4	7	2	2	15	3
18.1-24	3	9	2	I	15	3
24.1-30	2	12	5	1	20	4
30~1-36	4	9	11	I	25	5
36.1-40	2	7	15	5	29	5
DRY	14	88	148	44	294	53

** For other soils in the study, this table is generally described in the narrative.

Prince William County Water Table Monitoring Sites
at Camp Glenkirk

not to scale

Dirt Road

I Gas- Utility

I

Building

?.

Mature

4'

Jackland Soil

Well # 1

Hardwoods

20 inch datalogger

Jackland Soil

40 inch datalogger

0-2% slopes

44'

0-2% slope

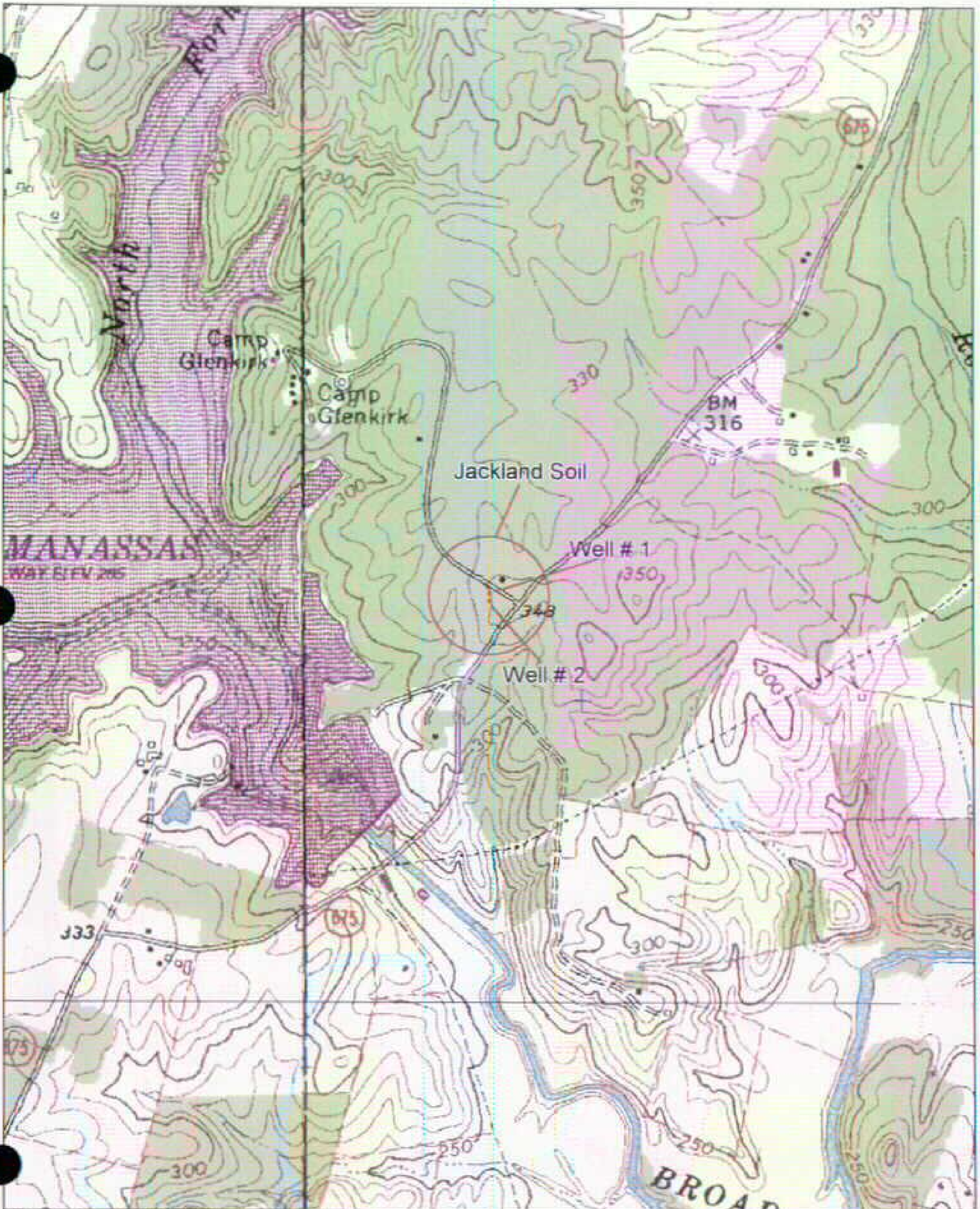
I J

Mature
Hardwoods

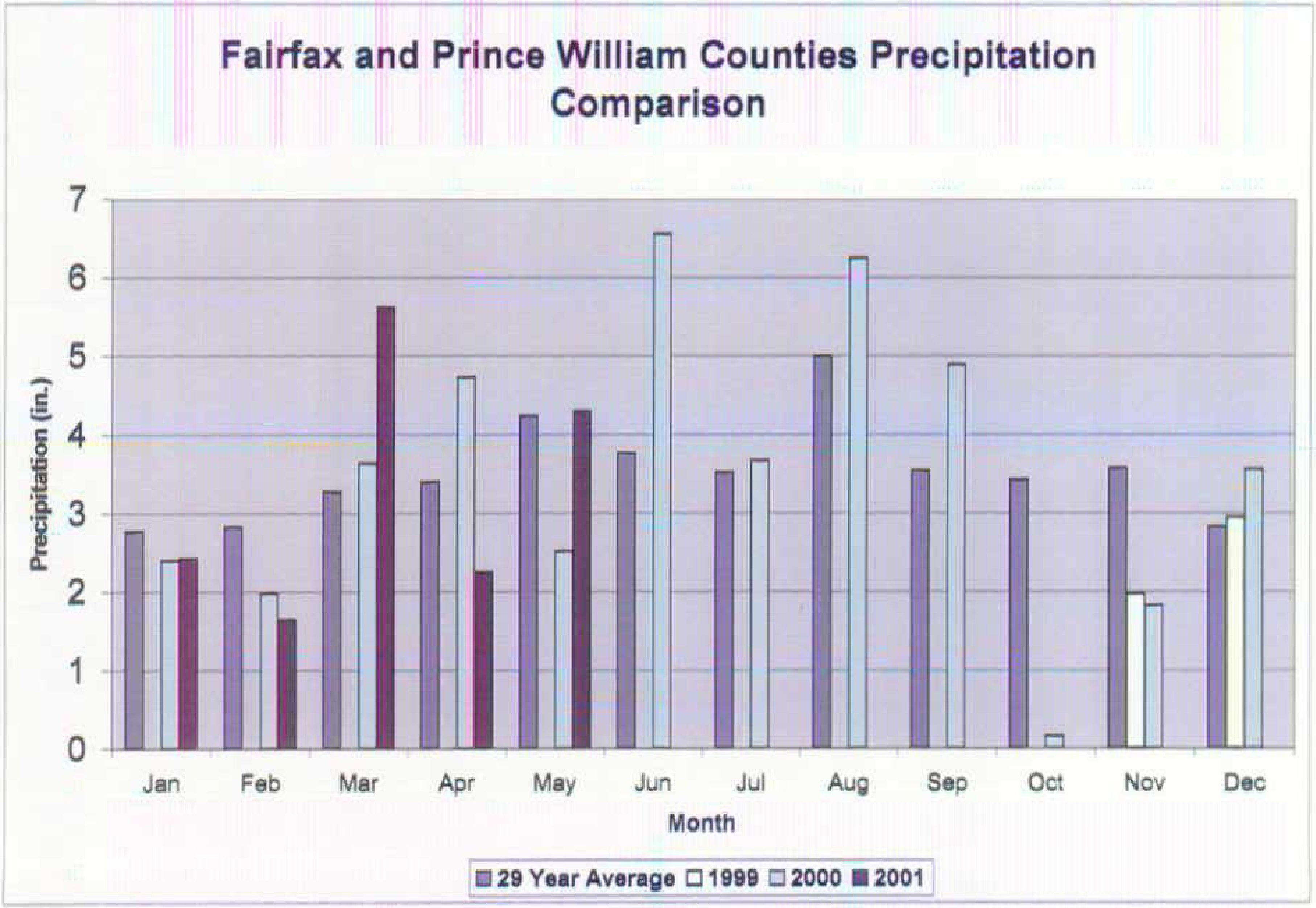
Hardwoods

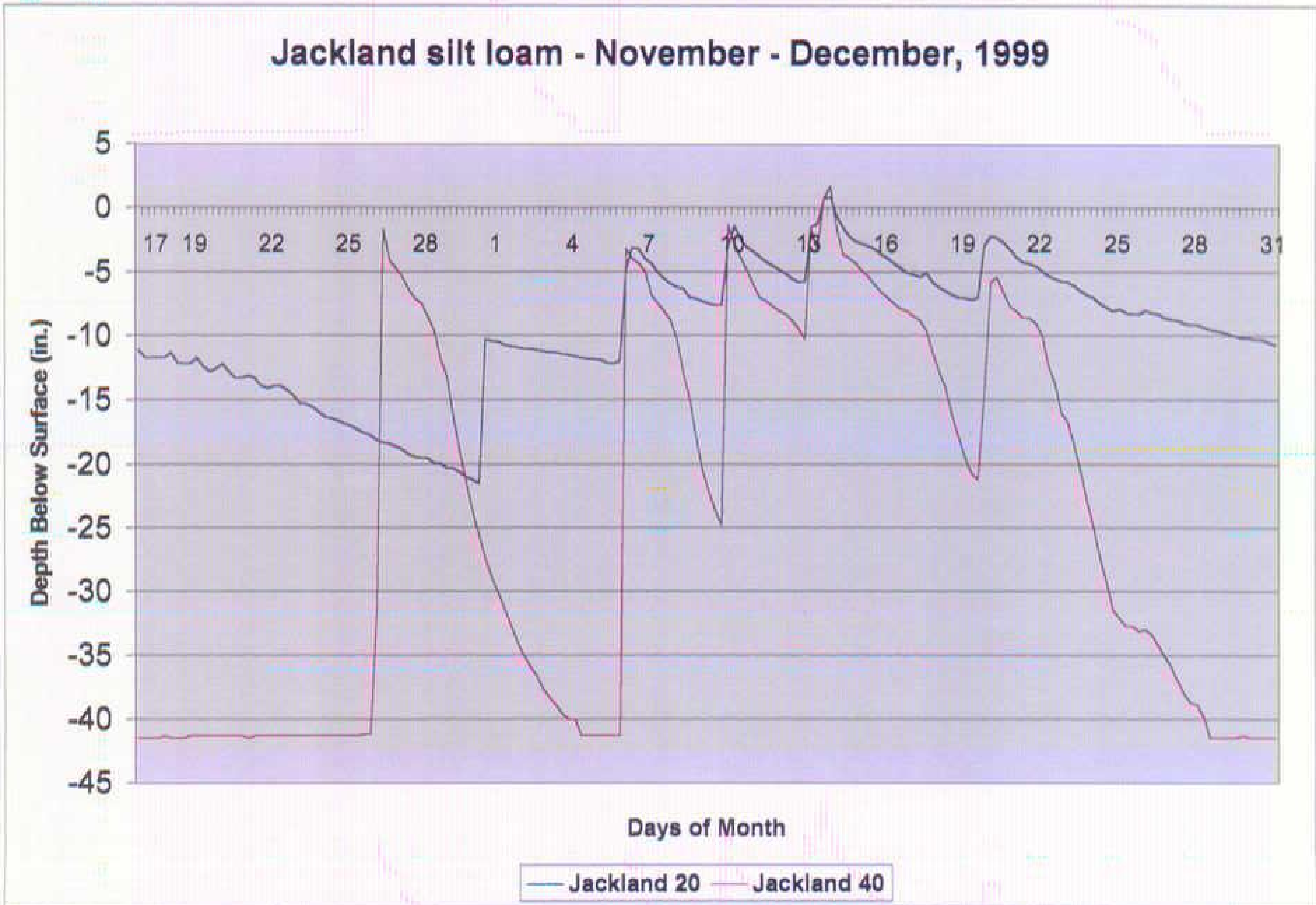
Gert y Sloping
Sideslope

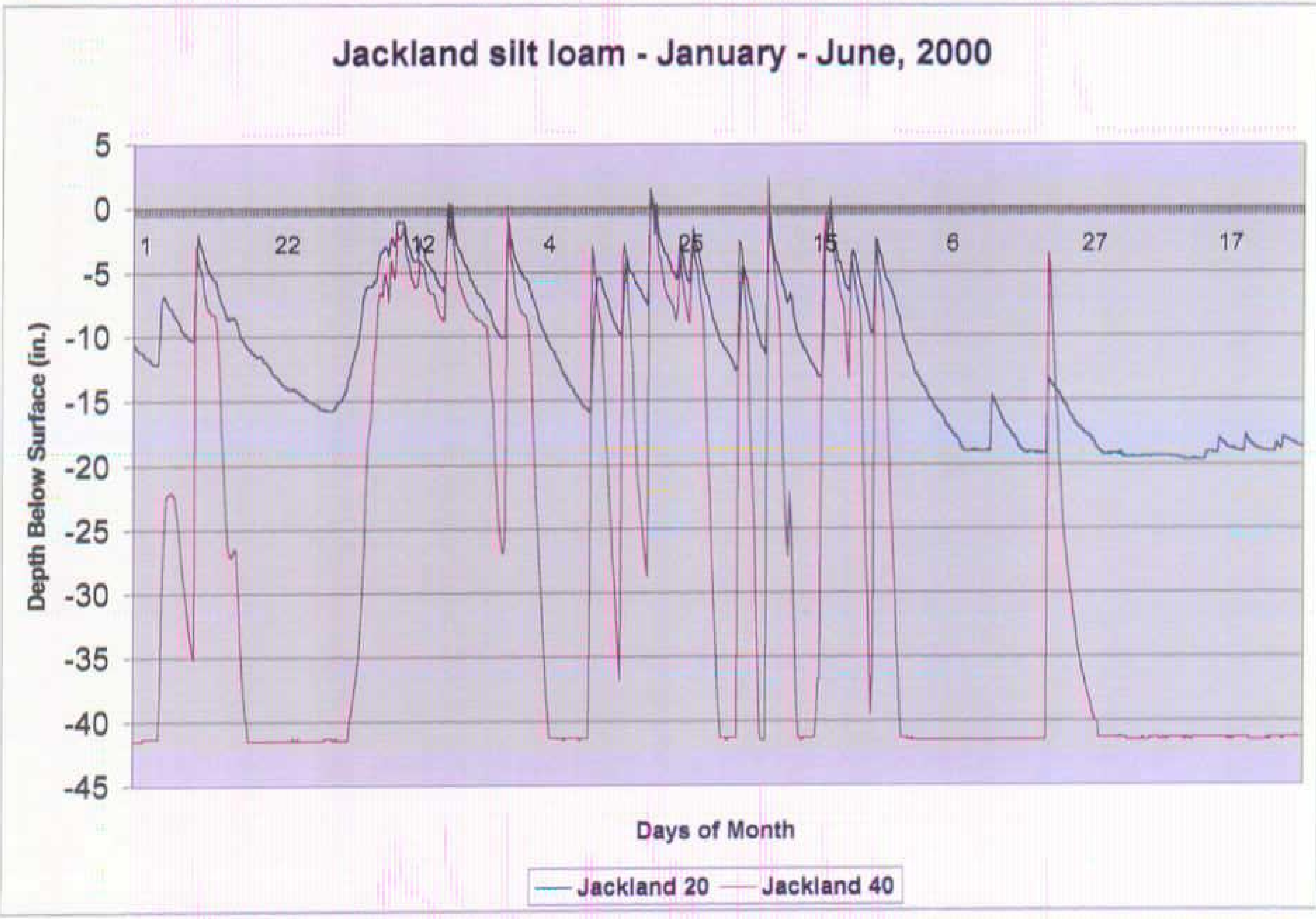
Mature
Hardwoods



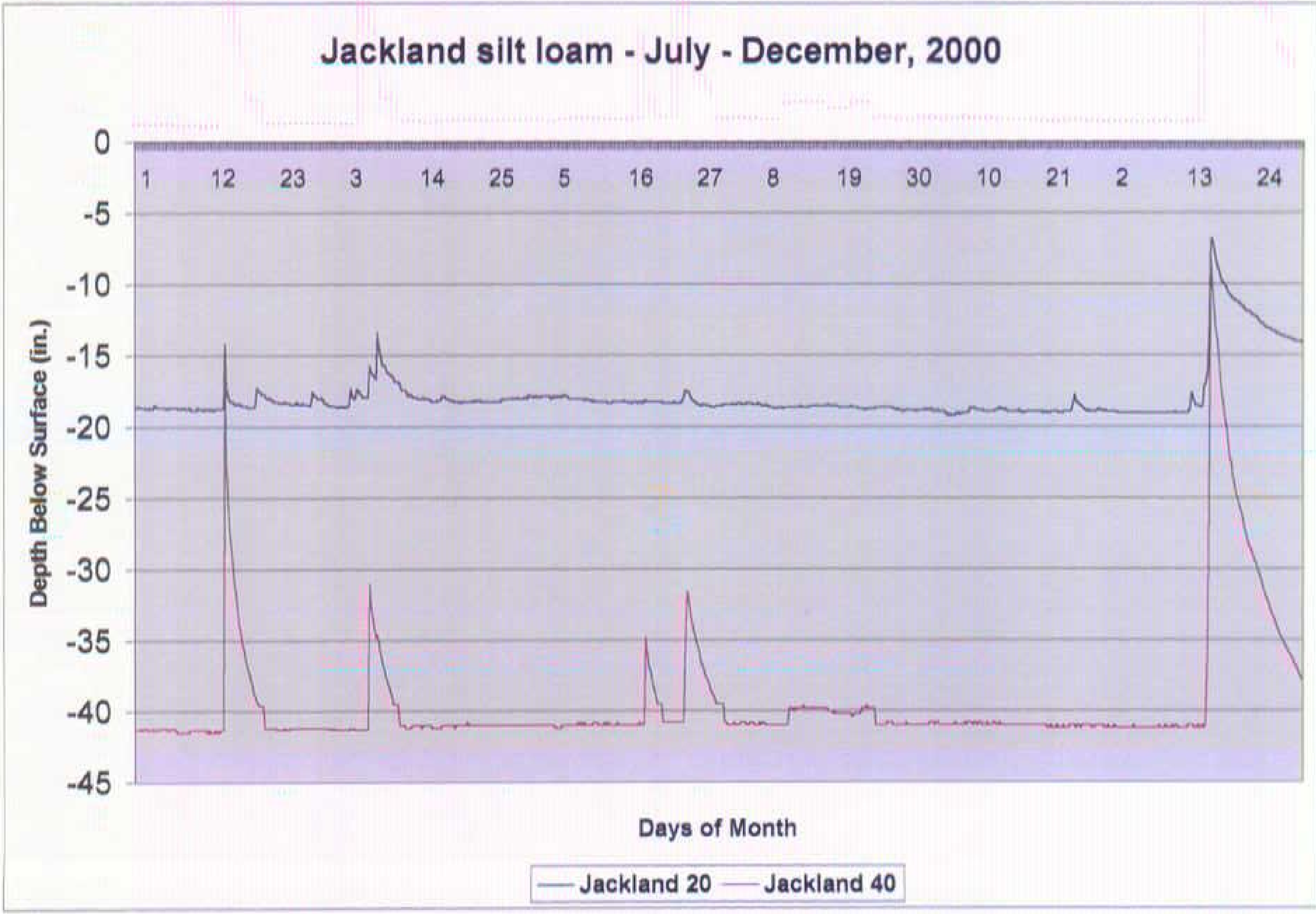
500 ft Scale: 1 : 12,800 Detail: 14-0 Datum: WGS84


Fairfax and Prince William Counties Precipitation Comparison
Precipitation (in.)
0
1
2
3
4
5
6
7
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month
29 Year Average
1999
2000
2001

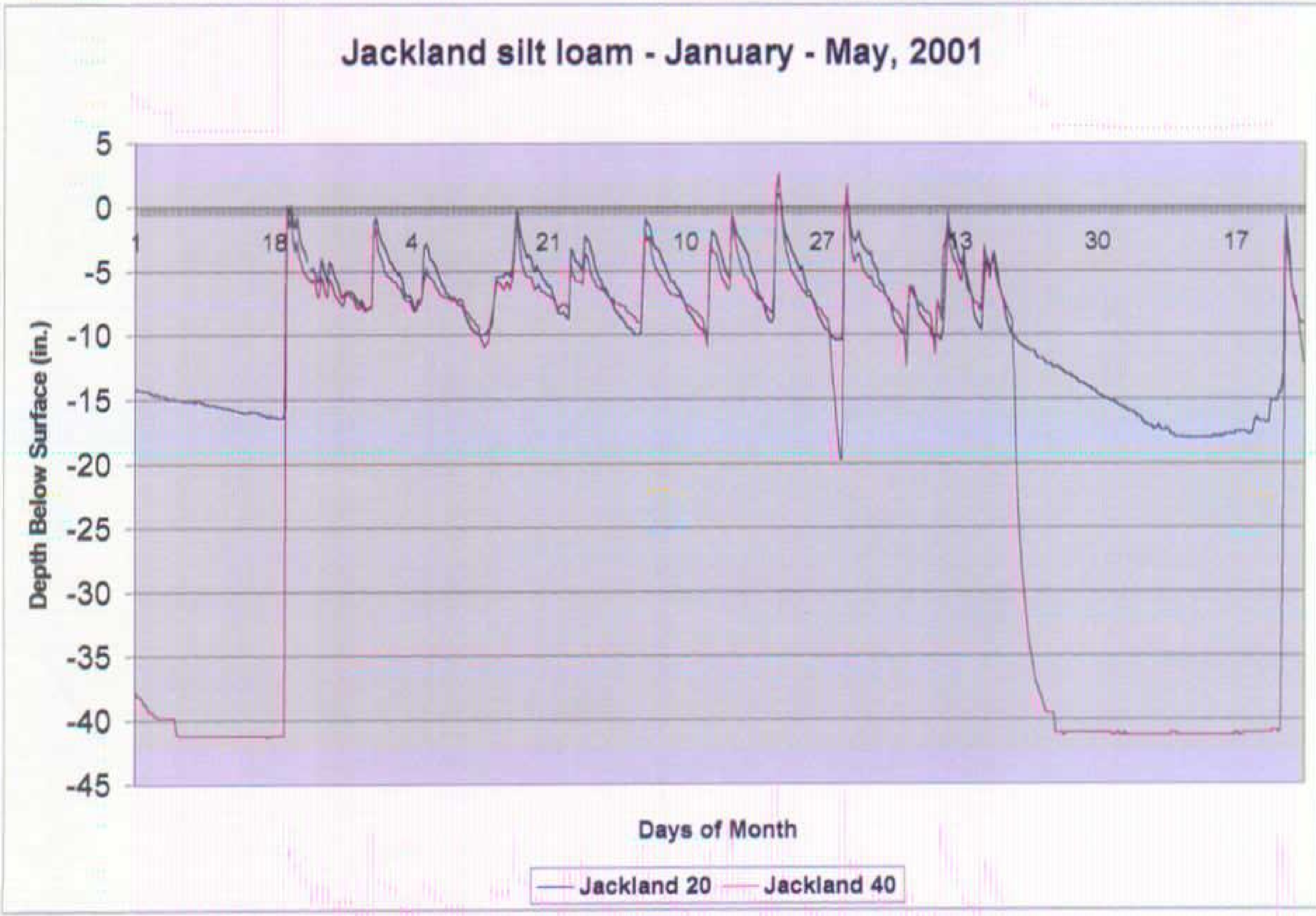

Jackland silt loam - November - December, 1999
Depth Below Surface (in.)
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
17 19 22 25 28 1 4 7 10 13 16 19 22 25 28 31
Days of Month
Jackland 20
Jackland 40



Jackland silt loam - January - June, 2000
Depth Below Surface (in.)
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
1
22
12
4
25
15
6
27
17
Days of Month
Jackland 20
Jackland 40



Jackland silt loam - July - December, 2000
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
Depth Below Surface (in.)
1
12
23
3
14
25
5
16
27
8
19
30
10
21
2
13
24
Days of Month
Jackland 20
Jackland 40


Jackland silt loam - January - May, 2001
Depth Below Surface (in.)
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
1
18
4
21
10
27
13
30
17
Days of Month
Jackland 20
Jackland 40

SOIL EVALUATED: KELLY SILT LOAM

LOCATION:

The study site is in the Piedmont province in the western part of Fairfax County, Virginia. The county boundary between Fairfax and Loudoun runs through part of the overall study site. Refer to the accompanying portion of the U.S. Geological Survey topographic map for the general topography and landforms. The accompanying site sketch shows the location of two automated data loggers in the Kelly soils and one automated data logger in the Penn soil (discussed in another part of the report).

RATIONALE FOR SITE SELECTION:

The study site is in the Triassic basin and has diverse geologic and soil dynamics occurring in a small area. The study site represents Triassic geology and soil that is .present over many thousands of acres in Fairfax, Prince William, Loudoun, Fauquier, and Culpeper Counties in. Northern Virginia. The monitoring wells are located close to a large, mass drainfield that appears to be functioning well. Information from the watertable study will give a reasonable idea of what groundwater levels are present in and around the mass drainfield. The total site will also be used to better define and delineate soil areas that are derived from redbeds and diabase or other igneous rocks.'

SOIL AND SITE INFORMATION:

The Kelly study site is in the Triassic basin of Northern Virginia. Triassic basin soils dominantly are reddish in color and derived from parent rocks called redbeds. These sedimentary redbeds consist of reddish shale, siltstone, fine-grained sandstone, mudstone, and some conglomerate. Throughout the Triassic basin, igneous diabase dikes have intruded the redbeds over geologic time. As the super-heated igneous dikes intruded the redbeds, they "baked" and altered the redbed materials they came in contact with. The lower part of the Kelly soils has developed in these "baked shales", hornfels, and granulites. The upper part of the Kelly soil has developed partly in periglacially (near glacial conditions) transported soil materials.

The Kelly monitoring wells are on a nearly level upland fiat or summit and estimated slopes range from 0 to 2 percent. The Kelly wells are in the edge of fairly dense cedar woods with some hardwood understory. The woods border a large open area that has the mass drainfield. Because of the flatness of the topography, it does not appear the drainfield has much influence on the watertable in the Kelly soils.

The Soil Survey of Fairfax CountY, Vir.clinia (H.C. Porter et al., 1963) and the Soil~ Survey of Loudoun CountY Vir.qinia (H.C. Porter et al., 1960) has the general soil area mapped (Fairfax County--Sheet 14; Loudoun County--Sheet 48) as Kb: Kelly silt loam, undulating phase and Pm: Penn silt loam, undulating phase.

A detailed soil profile description was made at each monitoring well site using a hand auger. When compared to the official soil series description for the Kelly soil (refer to the Appendix), the Kelly soils at the study site generally fall within the range of characteristics, especially for drainage and permeabilitY. More importantly, the Kelly soils appear to fit.the concepts in the older soil surveys cited above.

CLIMATIC DATA FOR THE STUDY SITE:

The Kelly study site is about 12 miles east of The Plains. Weather data from The Plains (1999, 2000, 2001, and 29-year average) was used to provide yearly and monthly precipitation figures for the study site. The precipitation comparison graph for Fairfax and Prince William Counties shows how each monthly precipitation total compares to the monthly 29-year averages (1961-1990).

During the November-December 1999 study period, precipitation was below normal. Rainfall for the two months totaled 3.79 inches, which is 2.61 inches less than the 29-year average total of 6.40 inches. In addition, much of Virginia was having drought conditions during 1999 and 2000. However, Kelly # 2 soil still had a perched watertable during the November-December 1999 study period.

During the January-June 2000 study period, total precipitation was 21.79 inches, which was 1.54 inches more than the 29-year average of 20.25 inches. June had the most precipitation at 6.55 inches followed by April with 4.72 inches. (June had the highest total for any month during the study period form November 1999 to May 2001.) February had the lowest precipitation of 1.98 inches during the January-June 2000 study period.

Duri.ng the July-December 2000 study period, total precipitation was 20.33 inches, which is 1.55 inches less than the 29-year average of 21.88 inches. August had .the highest total precipitation at 6.24 inches, and October had the lowest total at 0.16 inches. (October 2000 was also the driest month in many other parts of eastern and central Virginia. Only 0.05 inches were recorded in the Fredericksburg area during the study period.) The anomalous dry October only serves to emphasize how well annual precipitation is distributed in Virginia.

For the final study period form January-May 2001 (Kelly watertable monitoring ended May 25), total precipitation was 16.21 inches, nearly the same as the 29-year average of 16.49 inches. March had the highest total at 5.61 inches while February had the lowest total at 1.64 inches.

For the entire study period beginning November 1999 and ending May 2001, total precipitation was about normal as compared to the 29-year average. The major deviations were the relatively dry months near the end of 1999, the relatively wetter than normal months of June and August in 2000, and the much drier than normal month of October 2000. Overall, the Kelly soil study site received sufficient precipitation' to allow natural watertables to occur.

RESULTS:

Automated data loggers (VVL-40) were installed at 40 inches below the soil surface in two different Kelly soil sites (Kelly I and Kelly 2). The monitoring wells are about 200 feet apart and are on the same nearly level upland fiat. The soils are in the edge of hardwood and cedar woods. The 40-inch wells were grouted with bentonite so that the monitoring was basically in the lower part of the soils. Continuous automated data collection began on December 1, 1999 and ended on May 25, 2001. During this period the wells were taking watertable readings 4 times a day. /

The Kelly soil is widespread in the Triassic basin. It is closely tied to the geology where diabase has intruded Triassic redbeds. Soil can change abruptly with a change in the geology. The Kelly soil does not meet the criteria of the Virginia Sewa,qe Handlinq and Disposal Re,qulations (2000) for a conventional septic system drainfield. The watertable study will shed some light on how wet this soil is, especially when the Kelly soil occurs as an inclusion in other more suitable Triassic redbed soils.

The watertable hydrograph for Kelly 1 and Kelly 2 for December 1999 shows that Kelly 1 stayed dry for the entire month (or watertable level dropped below the monitoring level of about 40 inches). Kelly 2 started out dry also, but the watertable skyrocketed to about 7 inches below the soil surface December 14 and stayed in the profile until June 2000. The prominent spike in the Kelly 2 can not be correlated to total precipitation in November-December 1999, since these months only had 4.92 inches of precipitation, as compared to the 29-year average of 6.4 inches. Again, this study only takes into account total precipitation for a month, and not the distribution of the precipitation.

The Kelly 1 and Kelly 2 Groundwater Data Table (GWDT) for December 1999 shows that Kelly 1 was dry for 31 days. The Kelly 2 was dry for 14 days, but had the surface of free water measured in some part of the soil from 0 to 40 inches for 17 cumulative days, or 55% of the time. Roughly, the watertable was in the A and EB horizons for 15 cumulative days, or 48% of the time.

The January-June hydrograph for Kelly I and 2 shows that both wells had a watertable for most of the period. Kelly 1 did not get wet until mid February, but once it did it stayed wet until mid June. From mid February to late April, Kelly I watertable fluctuated mostly between 5 to 25 inches below the soil surface. The Kelly 2 watertable was consistently higher than the Kelly 1, with fluctuations mostly between 2 to 20 inches below the soil surface. Both wells showed a big drop in watertables in May that coincided with spring time leafing-out and increasing evapotranspiration. The trends in both wells started to mirror each other beginning about mid February.

The January-June 2000 GVVDT for Kelly I and 2 shows that the surface of free water was measured between 0 to about 40 inches below the soil surface for 135 cumulative days (74% of the time) for Kelly 1 and 152 cumulative days (84% of the time) for Kelly 2.

For Kelly 1, free water was in the A and EB horizons for 26 cumulative days, or 14% of the 182 day period; free water was in the Bt1 and Bt2 for 76 cUmulative days, or 42% of the time; free water was in the Bt3 for 95 cumulative days, or 52% of the time; and free water was in the 2BCt for 135 cumulative days, or 74% of the time. (Note: It must 'be remembered that when the surface of the watertable is at shallower depth range or horizons, it is assumed a lower depth range or horizon has free water in it also.) Kelly 1 was dry (or watertable level dropped below about 40 inches) for 47 days, or 26% of the time. The depth range from 18.1-24 inches had the most days when the surface of free water was measured in it

In the same January-June 2000 GWDT, Kelly 2 had the surface of free water in the ^ and EB horizons for 57 cumulative days, or 31% of the time; free water was in the Bt1 horizon for 104 cumulative days, or 57% of the time; free water was in the Bt2 horizon for 129 days, or 71% of the time; and free water was in the Bt3 horizon for 152 days, or 84% of the time. Kelly 2 was dry for 30 days, or 17% of the time.

The July-December 2000 hydrograph for Kelly 1 and 2 shows the trends were mostly similar, but the wells reversed hydrology and Kelly I was much wetter than Kelly 2 in July and August. In October both wells dried out and stayed that way until December. In July and August, Kelly 1 watertable fluctuated mostly between 5 to 35 inches below the soil surface, while Kelly 2 was either dry or between 35 to 40 inches. The Kelly 1 had somewhat higher and sharper peaks than the Kelly 2.

The Kelly 1 and 2 GVVDT for July-December 2000 shows Kelly 1 had the surface of free in some part of the soil between 0 to 40 inches for 112 cumulative days, or 61% of the time. The Kelly 2 had a free water surface for 68 cumulative days, or only 37% of the time. Most of the Kelly 2 readings were below 30 inches or more.

For Kelly 1, free water was in the A and EB horizons for 10 cumulative days, or 5% of the time; free water was in the Bt1 and Bt2 horizons for 34 cumulative days, or 19% of the time; free water was in the Bt3 horizon for 47 cumulative days, or 26% of the time; and free water was in the 2BCt horizon for 112 cumulative days, or 61% of the time. There were 72 dry days. Kelly 2 levels were quite different; the watertable was absent in the upper horizons and was measured only in the Bt3 hodzon for 68 cumulative days, or 37% of the time. There were 116 dry days .(when the watertable dropped below about 40 inches). This role reversal is hard to explain based on the soil features and properties in both profiles. Both Kelly I and Kelly 2 have clayey Bt horizons with pronounced restrictive permeability.

The January-May 2001 Kelly I and 2 hydrograph shows that both wells were generally dry until late March, when they both spiked to less than 10 inches below the soil surface. The trends were similar and Kelly 2 was again wetter than Kelly 1. The big drops in both wells in late April coincided with springtime leafing-out and increasing evapotranspiration.

After being so different in previous periods, watertable levels in the Kelly 1 and Kelly 2 GVVDT for January-May 2001 are remarkably similar. For Kelly 1, the surface of free water was measured in some part of the soil between 0 to 40 inches for 71 cumulative days, or 49% of the time, while for Kelly 2 it was 67 days, or 46% of the time.

For the Kelly 1 soil, free water was in the A and EB horizons for 3 cumulative days, or 2% of the time; free water was in the Bt1 and Bt2 horizons for 22 cumulative days, or 15% of the time; free water was in the Bt3 horizon for 31 cumulative days, or 21% of the time; and free water was in the 2BCt horizon for 71 cumulative days, or 49% of the time. There were 74 dry days recorded.

For the Kelly 2 soil, free water was in the ^ and EB horizons for 18 cumulative days, or 12% of the time; free water was in the Bt1 horizon for 27 cumulative days, or 19% of the time; free water was in the Bt2 for 36 cumulative days, or 25% of the time; and free water was in the Bt3 hodzon for 67 cumulative days, or 46% of the time. There were 78 dry days recorded, only 4 more than the Kelly 1 had.

CONCLUSIONS:

The Kelly 1 and Kelly 2 soil were wet a majority of the time. For Kelly 1, a free water surface was measured in some part of the soil between 0 and 40 inches below the soil surface for 318 days, or 59% of the 542 days in the December 1999 to May 2001 study period. For Kelly 2, the figures were 304 days, or 56% of the time.

Kelly 1 had 224 dry days, which were recorded when the free water surface dropped below the monitoring level of 40 inches or more. Kelly 2 had 238 dry days. This small difference of only 14 days in the total number of dry days is probably the most remarkable comparison between the two monitoring wells. It was expected that both Kelly soils would have a perched watertable and soil wetness problems, based on morphological features, restrictive permeability, and the fiat landscape that allows for minimal runoff. The two well sites could have had a great disparity in total dry days, since the profiles have some differences in morphology and properties, and they are 200 feet apart. Potentially, the dry day disparity could have mimicked what commonly happens when a percolation or saturated hydraulic conductivity (Ksat) test is conducted in fine textured and restrictive permeability soils. The water movement results can be so variable that application of the data is essentially useless for something as simple as designing a drainfield. Also, the closeness of the .total dry days (or closeness of total wet days) between the 'two Kelly soils also serves to enhance the comfort level regarding monitoring well installation and recordation of the data.

When data logger depth ranges are grouped together to roughly correspond with the horizon depths described for the Kelly 1 soil, it can be seen that the A and EB horizons (0 to 12 inches) had the surface of free water measured in them for 39 days, or 7% of the time; free water surface was in the Bt1 and Bt2 horizons (12-24 inches) for 93 days, or 17% of the time; free water surface was in the Bt3 horizon for 41 days, or 8% of the time; and the free water surface was in the 2BCt horizon (30 to 40 inches) for 145 days,. or 27% of the time. (Again, it is assumed that when there is free water in the Bt3 horizon, there is also free water in the lower 2BCt horizon. This is dealing with cumulative wet days, which is different from the total days a free water surface was measured in a depth range or horizon.)

For the Kelly 2 soil during the entire 542 day study, depth ranges grouped together indicate the surface of free water was measured in the A and EB horizons (0 to 12 inches) 90 days, or 16% of the time; free water surface was in the Bt1 horizon (12-18 inches) for 57 days, or 11% of the time; free water surface was in the Bt2 horizon (18 to 30 inches for 36 days, or 7% of the time; and free surface was in the Bt3 horizon 30 to 40 inches) for 121 days, or 22% of the time.

Gray mottles, (also called redoximorphic or soil wetness features) indicate a soil has a seasonal watertable and/or periodic soil wetness. Gray mottles are diagnostic for soil wetness in Virginia's sewage regulations and where the grays begin is one of the main factors for determing drainfield site suitability and design of the system. The Regulations state that the depth at which gray mottles begin in a soil is the beginning of the watertable. This use of gray mottles for watertable or soil wetness determination is used throughout the United States for other wastewater programs. Also, gray mottles and gray soil colors are used to map and classify soils in the United States and many other countries.

In the Kelly I soil, gray mottles begin at 24 inches below the soil surface. However, there were 132 days (24% of 542 days in study period) when the free water surface was measured in some part of the soil from 0 to 24 inches below the soil surface. In the Kelly 2, gray mottles begin at 19 inches below the soil surface, ye{ the free water surface was measured in some part of the soil from 0 to 19 inches below the soil surface for 147 days, or 27% of the total 542 days in the study period. This clearly shows that the watertable in both soils was closer to the surface than the gray mottles indicated. There were other soil wetness features above the gray mottle beginning depths in both soils. Kelly 1 had chroma 3 and 4 mottles (pale mottles), yellowish red iron segregation mottles, and abundant manganese oxide stains and coatings from 0 to 24 inches below the soil surface. Likewise, Kelly 2 had chroma 4 mottles and manganese stains, coatings, and small concretions above the 19-inch depth where gray mottles began.

Virginia Department of Health environmental health specialists and soil scientists who work in the onsite wastewater treatment and disposal program have always known that watertables are generally shallower than the depth at which gray mottles begin. However, quantifying and defining the limiting or unacceptable amounts of these "alternative" soil wetness features is more difficult than simply using gray mottles as the main watertable indicator. Also, a soil can be wet but have few to no gray mottles because the factors and soil conditions that produce gray mottles are not "just right" or optimum. An example of this is chroma 3 and 4 mottles. They generally indicate soil wetness, but they are not gray. Is the soil not wet enough over time? Is the soil temperature too cold for the iron reducing bacteria to optimally function? Does the soil lack organic compounds (especially at deep depths) as an energy source for the reducing bacterial? Gray mottle formation in soils is a complex back and forth process that involves reduction and oxidation.

Based on the watertable results in the Kelly soils and other soils in the overall study, it is recommended that chroma 3 and 4 mottles be considered as a strong field clue for seasonal watertable and/or soil wetness in determining drainfield suitability. Probably, a chroma 3 and 4 mottle determining limit should only apply to soils where the abundance of mottles is many (20% or more of the surface area in a horizon), and the soils are dominantlY fine textured or have restrictive permeability.

Kelly silt loam

Soil Profile for Well # 1 (WL-40)

A--0 to 1 inch: very dark grayish brown (10YR 3/2) silt loam; very friable, slightly sticky, slightly plastic; 0 to 1% fine gravel.

EB--1 to 9 inches; dark yellowish brown (10YR 4/4) loam; friable, slightly sticky, slightly plastic; 0 to 1% fine gravel.

Bt1--9 to 15 inches; strong brown (7.5YR 4/6) clay loam; common fine faint light yellowish brown (10YR 6/4) mottles; common fine distinct very dark gray (10YR 3/1) manganese oxide stains and coatings; friable, slightly sticky, slightly plastic; 1 to 3% fine shale and 'quartz gravel.

Bt2--15 to 24 inches; strong brOwn heavy clay loam; many medium distinct light yellowish brown (10YR 6/4) mottles; common fine distinct yellowish red (5YR 4/8) mottles; firm, sticky, plastic; few fine prominent very dark gray (10YR 3/1) manganese oxide stains and coatings; 1 to 3% quartz and shale fine gravel.

Bt3--24 to 31 inches; red (2.5YR 4/6) clay; many medium distinct light yellowish brown (10YR 6/4) mottles; common medium distinct light gray (10YR 7/2) and very pale brown (10YR 7/3) mottles; very firm, sticky and very plastic; high shrink-swell potential; restrictive permeability; 0 to 1% fine gravel.

2BCt--31 to 47 inches; mixed strong brown (7.5YR 4/6)and light yellowish brown (10YR 6/4) clay loam; common medium distinct very dark gray (10YR 3/1) manganese oxide stains and coatings; firm, sticky and plastic; I to 5% quartz and shale fine gravel.

2CB--47 to 60 inches; light yellowish brown (10YR 6/4) and brownish yellow (10YR 6/6) parent material mixed with strong brown (7.5YR 4/6) clay flows; textures to very gritty sandy clay loam; few fine distinct very dark gray (10YR 3/1) manganese oxide stains and coatings; firm, sticky, slightly plastic; 1 to 5% very fine quartz? fragments.

Kelly silt loam

Soil Profile for Well # 2 (WL-40)

A--0 to 3 inches; very dark grayish brown (10YR 3~2) silt loam; friable.

EB--3 to 9 inches; brown (10YR 4/3) heavy loam; friable; few very fine manganese oxide concretions.

Bt1--9 to 19 inches; yellowish brown (10YR 5/4) heavy silty clay loam; common medium faint light yellowish brown (2.5Y 6/4) ped coatings; few fine (0.5 to 2.0 mm) manganese oxide concretions; few very dark gray (10YR 3/1) manganese oxide stains and coatings;. firm.

Bt2--19 to 29 inches; mottled light olive brown (2.5Y 5/4) light clay; many very dark.gray (10YR 3/1), yellowish brown (10YR 5/8), and light brownish gray (2.5Y 6/2) mottles; soil materials very firm, dense, and compact in place and have restrictive permeability; many manganese coatings and concretions; 2% partly rounded shale and quartz gravel.

Bt3--29 to 39 inches; mottled light olive brown (2.5Y 5/4), black (10YR 2/1), and very dark gray (10YR 3/1) gravelly clay; 15 to 20% manganese oxide concretions and some partly rounded quartz? gravel; soil materials very firm, dense, and compact in place and have restrictive permeability.

2Bt4--39 to 53 inches; dark yellowish brown (10YR 4/4) heavy clay; few fine specks of white parent material; soil materials are very plastic, have very high shrink-swell potential, and restrictive permeability; many pressure faces; common slickensides; 1 to 3% parent rock fragments less than 1/4 inch across.

2Bt5--53 to 60 inches; strong brown (7.5YR 4/6) clay; soil materials are very firm, plastic, and have high shrink-swell potential and restrictive permeability.

Table 1 - - Kelly silt loam Groundwater Data Table
December, 1999 (31 Days)
Fairfax County, Data Logger Well # 1 and # 2

	Well # 1			Percent	Well # 2			Percent
Depth Range (in.)	Number of Days	Percent Time	Cumulative Days	Cumulative Days	Number Of Days	Percent Time	Cumulative Days	Cumulative Days
0-6	0	0	0	0	1	3	1	3
6.1-12	0	0	0	0	14	45	15	48
12.1-18	0	0	0	0	2	7	17	55
18.1-24	0	0	0	0	0	0	17	55
24.1-30	0	0	0	0	0	0	17	55
30.1-36	0	0	0	0	0	0	17	55
36.1-40	0	0	0	0	0	0	17	55
Dry	31	100	31	100	14	45	31	:100

Table 2 - - Kelly silt loam Groundwater Data Table
January - June, 2000 (182 Days)
Fairfax County, Data Logger Well # 1 and # 2

	Well # 1			Percent	Well # 2			Percent
Depth Range (in.)	Number of Days	Percent Time	Cumulative Days	Cumulative Days	Number Of Days	Percent Time	Cumulative Days	Cumulative Days
0 -6	8	4	8	4	33	18	33	18
6.1-12	18	10	26	14	24	13	57	31
12.1-18	20	11	46	25	47	26	104	57
18.1-24	30	17	76	42	21	12	125	69
24.1-30	19	10	95	52	4	2	129	71
30.1-36	28	15	123	68	3	1	132	73
36.1-39.2	12	7	135	74	20	11	152	84
Dry	47	26	182	100	30	,17	182	100

Number of Day~ column refers to the number of days the surface of the free water was present within' the depth range.

Percentage of Time column refers to the percent of time the water was present within the depth range.

Cumulative Days column refers to the total number of days the water was present within the depth range.

Percentage of Cumulative Days refers to the percent of total time the water was present within the depth range.

DRY corresponds to the number of readings (converted to days) where the monitoring well recorded no water in the hole.

Days in the column headings corresponds to the number of data logger readings within a depth range divided by the number (normally 2, 4 or 8) of data logger readings per day.

Table 3 - - Kelly silt loam Groundwater Data Table
July - December, 2000 (184 Days)
Fairfax County~ Data Logger Well # 1 and # 2

	Well # 1				Well # 2			
Depth Range (in.)	Number of Days	Percent Time	Cumulative Days	Percent Cumulative Days	Number Of Days	Percent Time	ICumulativel Days	Percent Cumulative Days
0-6	4	2	5	3	0	0	0	0
6.1-12	6	3	10	5	0	0	0	0
12.1-18	5	3	15	8	0	0	0	0
18.1-24	19	10	34	19	0	0	0	0
24.1-30	13	8	47	26	1	1	1'	1
30.1-36	37	20	84	46	24	13	25	14
36.1-39.4	28	15	112	61	43	23	68	37
DRY	72	39	184	100	116	63	184	100

Table 4 - - Kelly silt loam Groundwater Data Table
January - May, 2001 (145 Days)
Fairfax County, Data Logger Well # 1 and # 2

	Well # 1				Well # 2			
Depth Range (in.)	Number of Days	Percent Time	Cumulative Days	Percent Cumulative Days	Number Of Days	Percent Time	Cumulative Days	Percent Cumulative Days
0-6	0	0	0	0	6	4	6	4
6.1-12	3	2	3	2	12	8	18	12
12.1-18	4	3	8	6	8	6	27	19
18.1-24	15	10	22	15	7	5	33	23
24.1-30	9	6	31	21	3	2	36	25
30.1-36	8	6	39	27	5	3	41	28
36.1-39.4	32	22	71	49	26	18	67	46
DRY	74	51	145	100	78	54	145	100

Number of Days column refers to the number of days the surface of the free water was present within the depth range.
Percentage of Time column refers to the percent of time the water was present within the depth range.
Cumulative Days column refers to the total number of days the water was present within the depth range.
Percentage of Cumulative Days refers to the percent of total time the water was present within the depth range.
DRY corresponds to the number of readings (converted to days) where the monitoring well recorded no water in the hole.
Days in the column headings corresponds to the number of data logger readings within a depth range divided by the number (normally 2, 4 or 8) of data logger readings per day.

**Table 5 - Kelly Well # 1 - Days Surface of Free Water Measured in a Depth Range

Depth Range (in.)	Dec 99	Jan-Jun 00	Jul-Dec 00	;Jan-May 01	Total Days	% Total Days
0 -6	0	8	4	0	12	2
6.1-12	0	18	6	3	27	5
12.1-18	0	20	5	4	29	5
18.1-24	0	30	19	15	64	12
24.1-30	0	19	13	9	41	8
30.1-36	0	28	37	8	73	14
36.1-40	0	12	28	32	72	13
DRY	31	47	72	74	224	41

** For other soils in the study, this table is generally described in the harrative.

**Table 6 - Kelly Well # 2 - Days Surface of Free Water Measured in a Depth Range
~542 DaYs)

Depth Range (in.)	Nov-Dec 99	Jan-Jun 00	Jul-Dec 00	Jan-May 01	Total Days	% Total Days
0 - 6	1	33	0	6	40	7
6.1-12	14	24	0	12	50	9
:12.1-18	2	47	0	8	57	11
18.1-24	0	21	0	7	28	5
24.1-30	0	4	1	3	8	2
30.1-36	0	3	24	5	32	6
36.1-40	0	20	43	26	89	16
DRY	14	30	116	78	238	44

** For other soils in the study, this table is generally desCribed in the narrative.

Fairfax County Water Table Monitoring Sites
at Fairfax National Golf Course

not to scale

IP/~~

Kelly Soil
-- - 100'

~_l~ Well # 2

i/ '72~,~/ / 40 inch datalogger
6,,

wooded

wooded '

Kelly Soil
Well # 1
40 inch datalogger

163'

Mass Drainfield

i

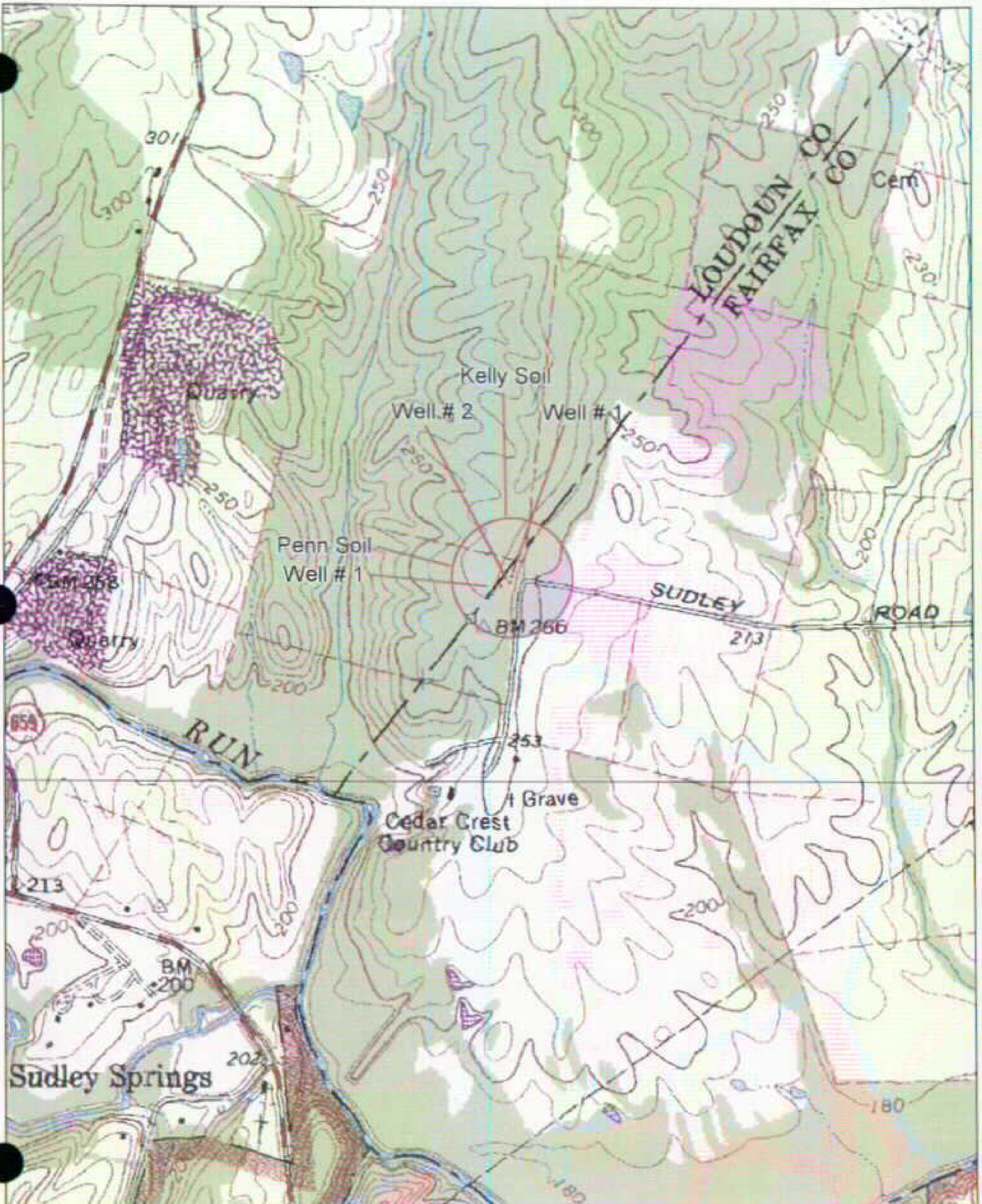
239'

Penn Soil
Well # 1

1 20 inch datalogger
145'

Dirt Road

Hangar/shed
250' x 80'



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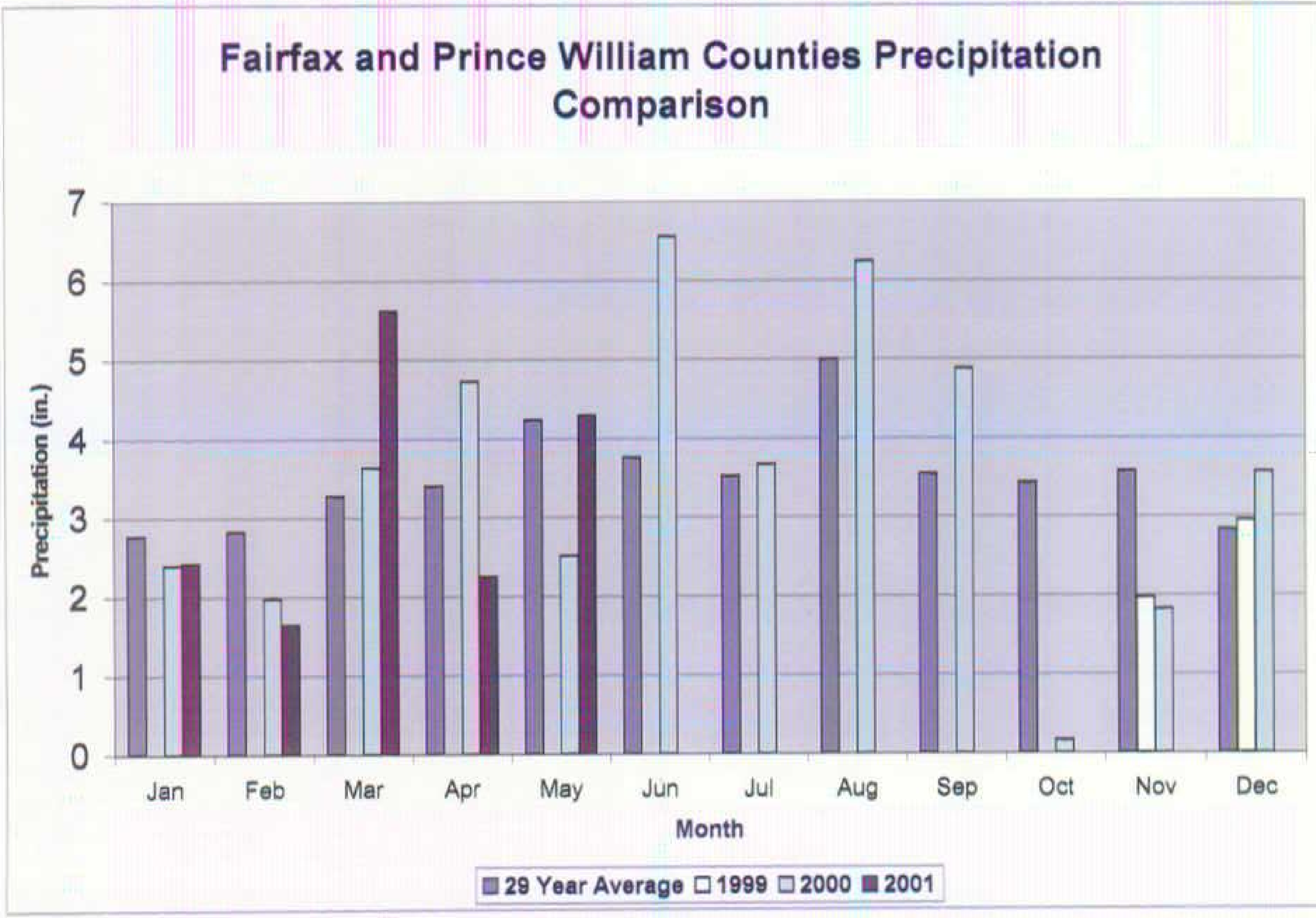
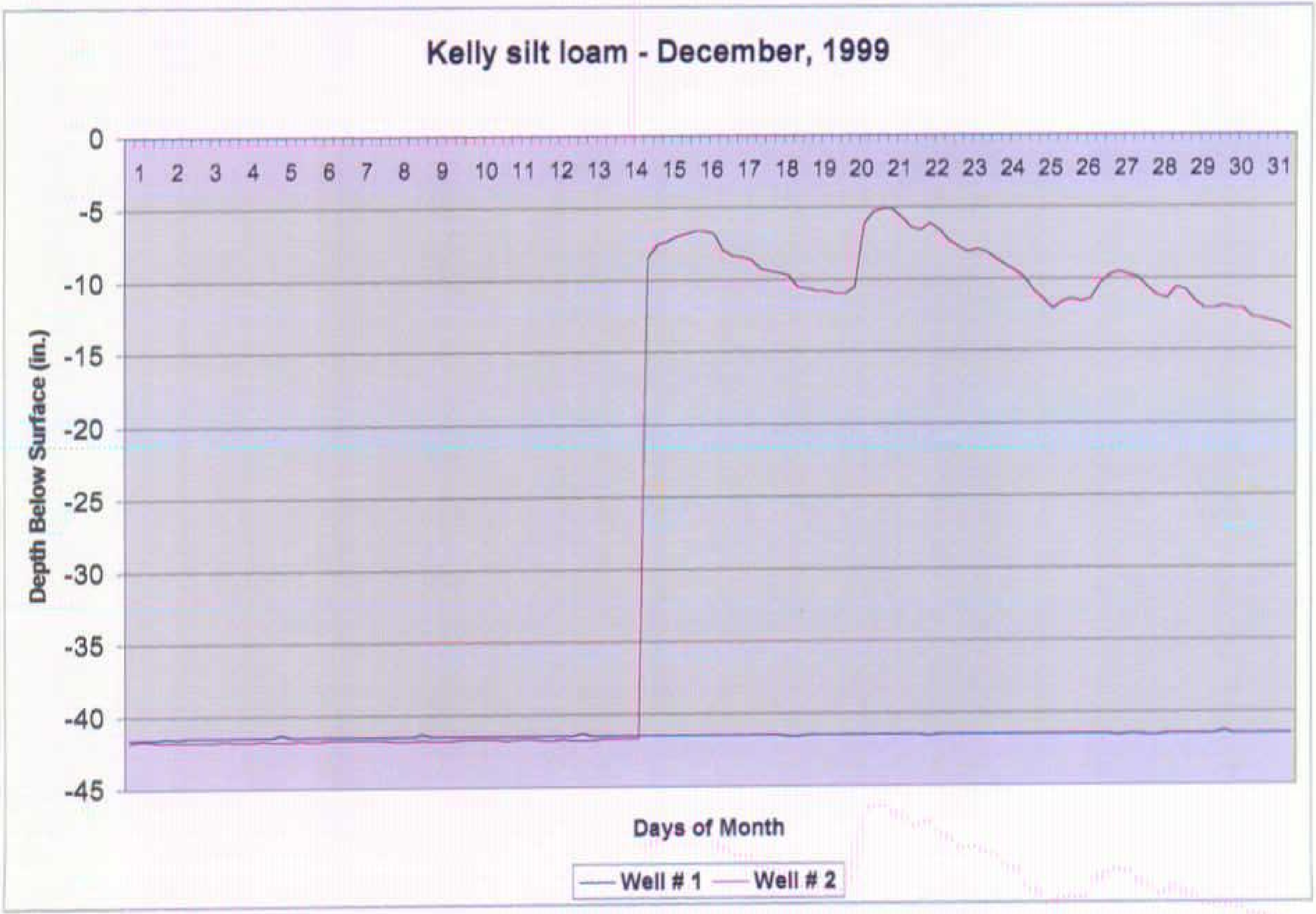
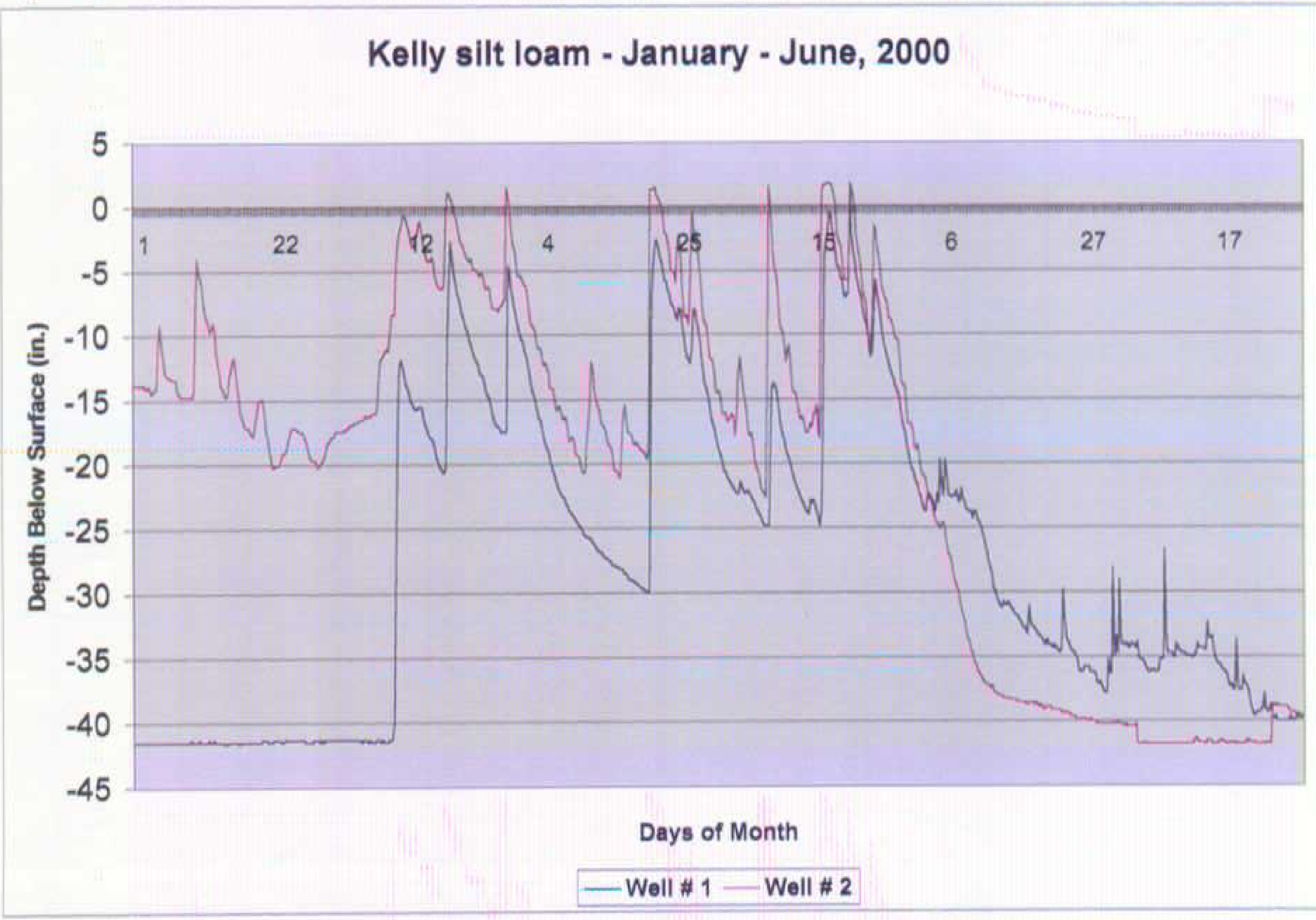
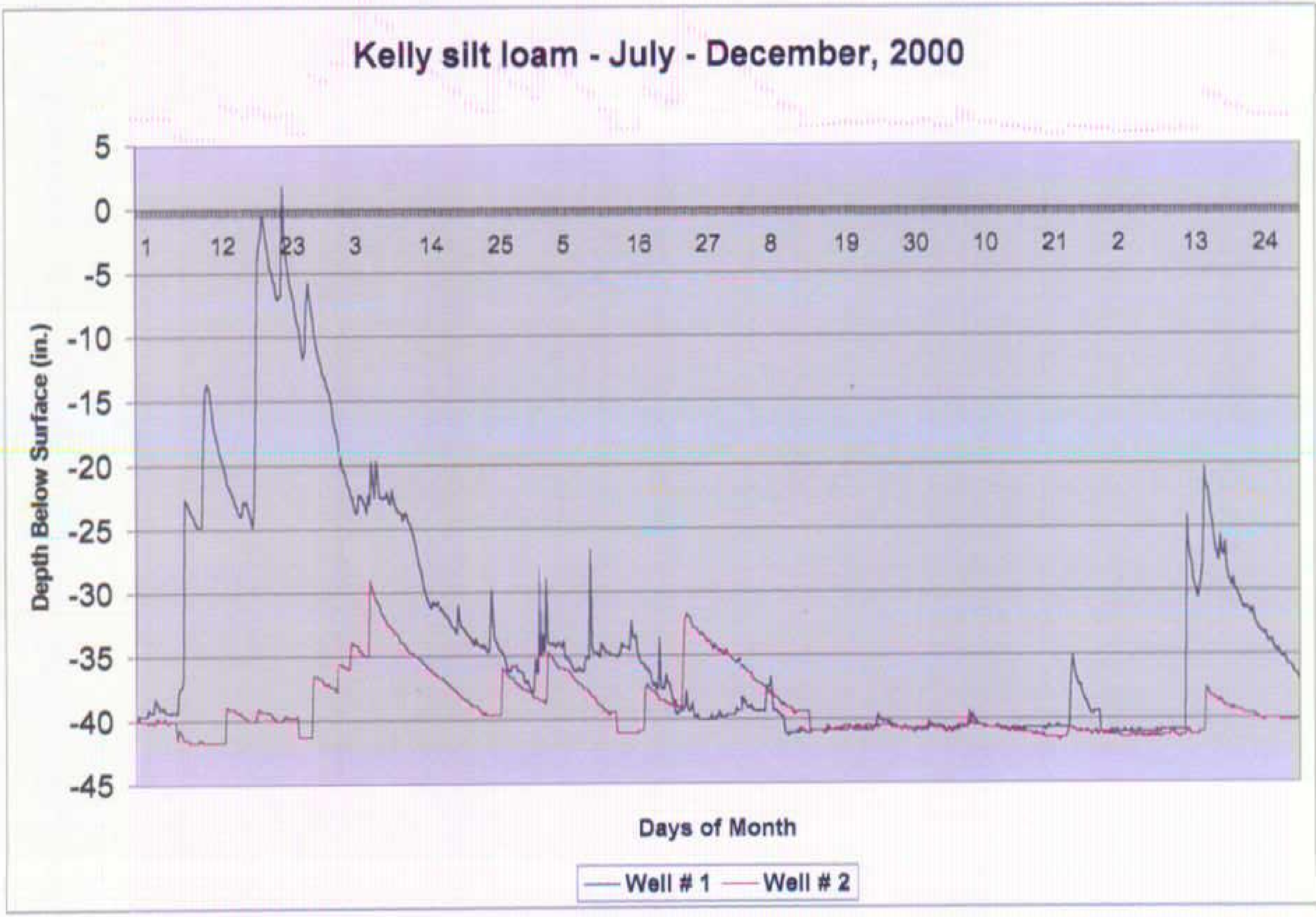

Fairfax and Prince William Counties Precipitation Comparison
Precipitation (in.)
0
1
2
3
4
5
6
7
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month
29 Year Average
1999
2000
2001

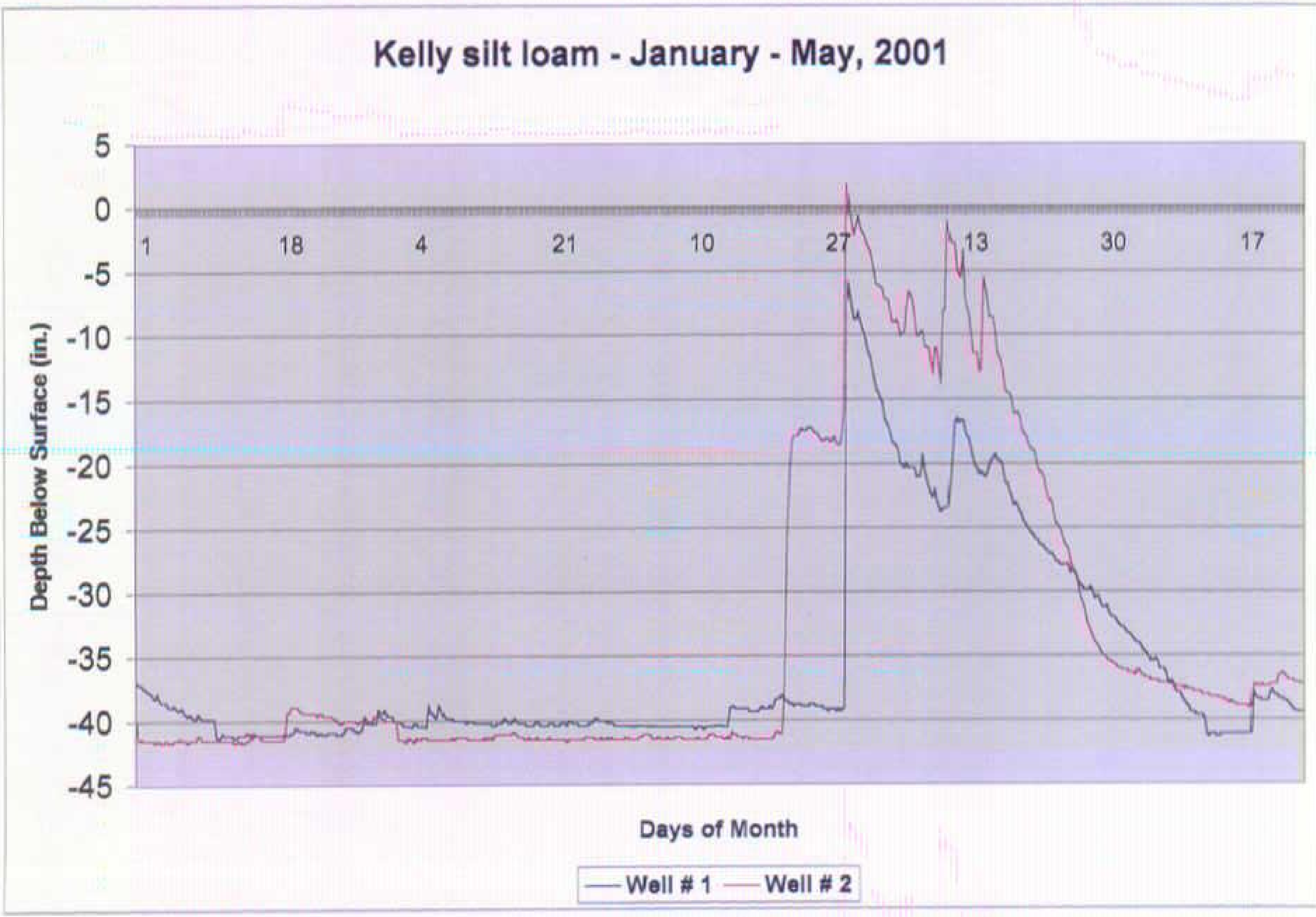


Kelly silt loam - December, 1999
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
Depth Below Surface (in.)
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
Days of Month
Well # 1
Well # 2



Kelly silt loam - January - June, 2000
Depth Below Surface (in.)
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
1
22
12
4
25
15
6
27
17
Days of Month
Well # 1
Well # 2


Kelly silt loam - July - December, 2000
Depth Below Surface (in.)
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
1
12
23
3
14
25
5
16
27
8
19
30
10
21
2
13
24
Days of Month
Well # 1
Well # 2


Kelly silt loam - January - May, 2001
Depth Below Surface (in.)
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
1
18
4
21
10
27
13
30
17
Days of Month
Well # 1
Well # 2

SOIL EVALUATED: Kinston silt loam

LOCATION:

This research site was located in the eastern portion of Hendco County, Virginia. Refer to the accompanying portion of the Dutch Gap U.S. Geologic Survey topogralShic map for the general character of the area. The accompanying detailed site sketch shows the location of two automated data loggers (a WL-40 and a WL-20) and two manual observation wells in Dorey Park.

RATIONALE FOR SITE SELECTION:

There were two reasons for using this site. The first was to better understand a known wet soil. And second, by using this soil as a benchmark, it might be possible to compare it with non-gleyed but wet soils, to better understand conditions necessary to produce gray mottle formation.

SOIL AND SITE INFORMATION:

The soil at this site formed in loamy and sandy, stratified, unconsolidated, recent alluvial sediments of the upper Coastal Plain. The study site was below a short, steep sideslope. The site was on a narrow floodplain adjacent to a small creek. The wells were in a wooded area, near a path used for recreational sports.

The Soil Survey'of Henrico County, Virginia (John W. Clay, 1975), shows the research site as being mapped as Kinston silt loam (Km). That is in agreement with the soils observed at the site.

A detailed soil profile description was made at the site and is included. When compared to the official soil series description for the Kinston series (refer to the Appendix), the soil at this site falls within the range of characteristics. That means the soil was typical or representative of Kinston soils.

CLIMATIC DATA FOR THE SITE:

The site was approximately 3.5 miles from the Richmond International Airport, where official NOAA weather data were collected, so precipitation data from the airport was used to evaluate rainfall during the study period. The precipitation comparison graph shows how each months rainfall total compares to the monthly 29-year averages (1961-1990).

It is apparent that for the November-December 1999 period, precipitation was well below normal. In fact, rainfall was only 42% of the long-term average for that two month span. Therefore, the water table levels at the site would be expected to be shallower (nearer to the surface) during a fall with normal precipitation.

For the period January-May 2000, total precipitation was only 0.23 inches above the 29-year average. That means that the water table levels would be expected to be representative of normal conditions at the site.

For the pedod July-December 2000, monthly rainfall was generally below normal. It is noteworthy that only 0.01 inches of rain was recorded for the entire month of October 2000, making it the driest October since data collection began in 1928 at the Richmond International Airport. The October-December 2000 pedod was extremely dry. In fact, rainfall was only 41% of the long-term average for that 3 month span. That dry fall situation was very similar to moisture conditions noted for November-December 1999. Therefore, the water table levels at the site would be expected to be shallower during a fall with normal precipitation.

For the period January-June 2001, monthly rainfall was generally below normal. January-May 2001 rainfall was 4.26 inches below the 29-year average, or 25% below normal. Therefore, the-water table levels at the site would be expected to be shallower during a winter and spdng with normal precipitation.

Except for a few exceptional wet months (April, June and August 2000; and June 2001), precipitation was normal to below normal. 'It should be noted that the original prOject completion date was extended due to severe drought conditions in most of the state during 1999. Fall 2000 thru spring 2001 was also well below normal. Therefore, only the January-May 2000 period had near normal precipitation, while the rest of the study period had below normal rainfall.

RESULTS:

A shallow and a deep automated data logger, a shallow and a deep manual observation well were installed on June 30, 1999. Wells were installed in the same soil, on the same landscape position, and at the same topographic elevation. Due to operator error, the automated wells were not programmed properly and the collection of water table data did not commence until November 18, 1999. There was continuous data collection from the starting date until June 30, 2001. The manual wells were read only when visiting the site to download data from the data loggers. The manual wells were not intended to gather water table data on a frequent basis; instead, they were used mainly as a check to see how closely the automated and manual wells corresponded.

The Kinston soil at this site had a grayish brown (10YR 5~2) gleyed matrix below 2 inches, making it a poorly drained soil. Normally, it would be assumed that the seasonal water table would be at or near the surface of the ground the majority of the time, while there might be brief pedods where it was below that depth.

The water table hydrograph of November-December 1999 shows the presence of free water in the soil at a depth of 14-16 inches for nearly a month, until mid-

December. The water level at this depth may relate to the drought in 1999, and that November 1999 precipitation was only 32% of normal. And while December rainfall was only 53% of normal, there was a sharp rise in depth of free water in the soil to 6 inches below the surface. The water level then dropped in a gradual, irregular pattern down to a depth of about 12 inches.

The November-December 1999 Groundwater Data Table shows that the surface of the free water was in the Btgl horizon 44 days, or 100% of the time during this 44 day period. During this drought period, the seasonal water table was always deeper than the gleyed colors and strong brown mottles in the Ag horizon.

The January-June 2000 hydrograph shows the water table fluctuated between 33 inches below the surface to slightly above ground surface from January thru early May. A rapid drop in the free water level starting in early May corresponds to shrubs and trees leafing-out and a rapid increase in evapotranspiration at the site. There is a portion of the line graphs missing, from January 3 to February 4, 2000. The wells at the site were vandalized and the batteries removed, so no data was collected during that period.

The January-June 2000 Groundwater Data Table shows that there were 32 days of missing data due to vandalism. When the percentages of time and cumulative days were determined, they were calculated on a data collection period of 150 days (ie, January-June 2000 had 182 days, minus 32 missing data days, equals 150 daYs of data collection). An additional note is that the few days where the free water waS above the ground surface have been included in the-0-6 inch depth range in the data table.

The January-June 2000 Groundwater Data Table showed that free water was in or above the A and Ag horizons for 66-90 days, or 44-60% of the time. Free water was in the Btgl horizon 138 days or 92% of the time during the 150 days data was collected. Free water was in the Btg2 horizon 150 days or 100% of the time. Free water was in the BCtg horizon 150 days or 100% of the time during the 150 days data was collected.

From February thru early May, the seasonal' water table was almost always within 6 inches of the ground surface, or above the surface, and there was always free water in the Btgl and Btg2 and BCtg horizons.

The July-December 2000 hydrograph shows numerous sharp spikes as the water table rose rapidly, with subsequent gradual declines in the water table level. There was a rapid rise in the water table in mid-December, and free water remained in the data loggers at a depth between 15-18 inches. The timing of the mid-December spike was very similar to the one seen in the November-December 1999 hydrograph. However, because of dry conditions in October and November 2000, the water table did not remain as shallow in the soil as was seen in 1999.

The July-December 2000 Groundwater Data Table shows that there were 18 days of missing data for Well #1 (WL-20) due to Iow charge on the batter. When the percentages of time and cumulative days were determined for Well #1, they were calculated on a data collection period of 166 days (ie, July-December 2000 had 184 days, minus 18 missing data days, equals 166 days of data collection).

The July-December 2000 Groundwater Data Table showed that free water was in the Btgl horizon 137 days, or 74% of the time during this 184 day period. Free water was in the Btg2 horizon for 180 days or 98% of this monitoring period. Free water was in the BCtg horizon for 184 days or 100% of the time.

The seasonal water table was shallower than 30 inches in depth, and there was almost always free water in the Btg2 and BCtg horizons during the July-December 2000 monitoring period.

The January-June 2001 hydrograph shows continuous saturation below a depth of 19 inches from January thru eady May. There was an exceptional rise in the free water level in late May, rising 27 inches in a 24 hour period. Numerous water table spikes were recorded with several coming close to, or above,' the ground surface. There was a gradual drop in the water table from mid-April to early May.

For the January-June 2001 Groundwater Data Table, the few days where the free water was above the ground surface have' been included in the 0-6 inch depth range in the data table.

The January-June 2001 Groundwater Data Table showed that free water was in the A and Ag horizons during numerous sharp spikes in the water table for 34-73 days, or 19-40% of the time. Water was in the Btgl horizon 177 days or 98% of the time during this 181 days period. Free water was in the Btg2 and BCtg horizons 100% of the time during this monitoring period.

The reality was that from January thru early May, the seasonal water table was always shallower than 19 inches, and there was always free water in the Btgl and Btg2 and BCtg horizons.

The included table shows the comparison of automated water level readings to the manual observation wells on specific dates. Earlier, it had been noted that two manual observation wells had been installed at the site, a shallow and a deep one. When the site was vandalized in January 2000, the shallow well was pulled out of the ground and the pipe taken from the site. Since only two water table readings had been taken from the shallow manual well, the shallow manual well was not included in the comparative data table. It should be noted that for these particular data loggers, the depth for a dry hole reading varied slightly over the entire test pedod. The bottom of the deep manual well was 44.7 inches below ground surface.

It is very clear that while all three wells were installed on the same date, in the same soil, and in the same landscape, there were discrepancies in the measured depths to the water table. There was never a recorded time where any of the three wells had the same reading. At times there might be two wells with very similar depth readings, yet on another date those same two wells might differ by 7 to 10 inches. The two data loggers consistently showed the depth to free water at a shallower depth than the manual well. While the two data loggers were at times generally close, at other times their water table depth measurements differed by almost 20 inches.

CONCLUSIONS:

This site had precipitation levels well below normal for the majority of the study period. In spite of that, free water was Present at shallow depths for the majority of the study. Even when the water table was depressed during the summer, it would respond quickly and spike upwards after summer thunderstorms.

Free water was observed in the A or Ag horizons for short periods of time, and was typically associated with precipitous rises in the water table. For the entire study period, free water was in these horizons from 102 to 165 days, depending on which data logger was taking the readings. During winter-spring periods, these horizons were saturated from 20-60% of the.time. The gleyed matrix of the Ag horizon and the many strong brown redoximorphic features could be related to the presence of water in the soil for the number of days observed. Under normal precipitation it would be expected that the seasonal water table would be in, or above, the A and Ag hodzons for significantly longer periods of time.

Free water was observed in the Btgl hodzon for extended periods of time. Water in the Btgl was characterized'by prolonged periods of saturation during winter-spring, with highly fluctuating water table levels in the summer. For the entire study period, free water was in the Btgl at least 496 days.

To really understand how wet the soil was, it should be noted that from mid-November 199 thru May 2000, and November 2000 thru June 2001, there was · always free water Present in the Btgl horizon.

The presence of a gleyed matrix and common strong brown and yellowish brown redoximorphic features (mottles) in the Btgl reflects the presence of the seasonal water table for extended periods of time. During the normally wetter times of the year, for two years in a row, the seasonal water table was 'present in the Btgl horizon almost continuously. It can only be expected that under normal precipitation, the seasonal water table would be in the gleyed Btgl horizon continuously.

It must be remembered that when the surface of the water table was in one of the upper horizons, the Btg2 was saturated. Free water was observed in the Btg2 horizon almost continuously for the entire study pedod. The BCtg hodzon was continuously saturated for the entire study period.

The presence of a gleyed matrix and strong brown, brownish yellow and yellowish brown redoximorphic features (mottles) in the Btg2 and BCtg horizons reflects the presence of continuous saturation. It can '0nly be expected that under normal precipitation, the seasonal water table would be in the gleyed Btg2 and BCtg horizons continuously.

Soil colors did not always clearly relate to the duration of soil wetness. The Btgl, Btg2 and BCtg horizons were almost continuously saturated and had a gleyed matrix with highly contrasting mottles. That was to be expected. The Ag horizon had saturation ranging from 20-60% of the time, Yet it also was gleyed with highly contrasting mottles. The fact that the Ag horizon was gleyed yet only. had free water present 20-60% of the time may relate to below normal precipitation during much of the study period. With normal rainfall, the Ag horizon might be saturated most of the time, and so its gleyed color probably reflects its normally saturated 'conditions. '

In addition, the presence of thread-like strong brown mottles along roots and' pores below 6 inches indicates that even when the macropores are drained, the soil matrix is still saturated, so the only zone for iron oxidation to occur is along ped faces, pores and roots. So even when there is no free water observed in a horizon, the matrix might still be under reduced conditions, promoting the formation of a gleyed horizon.

The comparison of automated versus manual observation wells clearly showed, at this site, that they were not in agreement. The three wells never had the same depth to the surface of the free water. Even though they were only 10-15 feet apart, there were times that the water level readings differed by more than 10 inches. This raised questions as to what was the real water table depth, and which well was truly accurate. "

The two data loggers, generally, had close agreement in their readings, which can be seen in the closely parallel hydrographs for each well. There is a remarkable consistency in when the two data logger wells spiked upwards, the height of the spikes and the duration of the water table rise. Because these two independent wells were so consistent, it raises questions about the reliability of the deep manual observation well.

It is difficult to understand why the three wells yielded such disparate results, since they were in the same soil and on the same landscape, and all wells were installed at.the same time, in a similarI~manner. The consequences of such disparity is that where wells might be used to assess site suitability for a septic system, utilizing only one observation well might merit issuing a septic permit while another well in another location might result in a rejection letter being sent. It appears that if wells are to be used to assess the septic suitability of a site, multiple Wells should be utilized, to allow for anomalies.

Kinston silt loam

Soil Profile for Well #1 (WL-20) and Well #2 (WL-40) and a Deep Manual Well

Am0 to 2 inches, dark brown (10YR 3/3) silt loam; friable, deformable, moderately sticky, moderately plastic, slightly fluid; very moist.

Ag--2 to 6 inches, grayish brown (10YR 5~2) fine sandy loam; many irregular medium distinct strong brown (7.5YR 5/8) masses of iron accumulation; friable, deformable, moderately sticky, slightly plastic, slightly fluid; very moist.

Btgl--6 to 25 inches, light brownish gray (10YR 6/2) sandy clay loam; few medium round pebbles (5-10 mm size); common irregular throughout medium distinct yellowish brown (10YR 5/6) masses of iron accumulation; and many threadlike medium prominent strong brown (7.5YR 5/6) masses of iron accumulation, predominantly along pores and roots; slightly sticky, slightly plastic, slightly fluid; at Field Capacity.

Btg2m25 to 36 inChes, light brownish gray (10YR 6~2) clay loam to heavy clay loam; common irregular throughout medium distinct brownish yellow (10YR 6/8) masses of iron accumulation; and common threads medium distinct yellowish brown (10YR 5/6) masses of iron accumulation; and many prominent strong brown (7.5YR 5/8) masses of iron accumulation- threads along roots and plates along ped faces; firm, deformable, moderately sticky, moderately plastic to very plastic, slightly fluid; moist.

BCtg~36 to 41 inches, light brownish gray (10YR 6/2) very gravelly clay loam; round quartz gravels vary from fine to coarse size; common irregular throughtout medium distinct brownish yellow (10YR 6~8) masses of iron accumulation; and common threads medium distinct yellowish brown (10YR 5/6) masses of iron accumulation; and many prominent strong brown (7.5YR 5/8) masses of iron accumulation- threads along roots and plates along ped faces; very sticky, moderately plastic, very fluid; saturated; auger refusal on rounded gravels.

Remarks: Profile taken in woods under oak and maple trees. Landscape position- slightly hummocky floodplain, adjacent to a small creek. Profile described on January 6,2000. 0% slope. Moist soil consistence noted only to a depth of 6 inches, because soil was wet below that depth.. Water began accumulating in hole below 20 inches, and when reached 30 inch depth the water rapidly rose in hole to 18 inches below land surface. After a few minutes the free water in the borehole was stabile at 12 inches below land surface, and remained at that depth for the remainder of the site visit.

Table I - - Kinston silt loam Groundwater Data Table
November-December, 1999 (44Days)
Dorey Park, Data Logger Well # 1 & ~2

Well # 1				Percent	Well # 2			Percent
Depth Range (in.)	Number of Days	Percent Time	Cumulative Days	Cumulative Days	Number of Days	Percent Time	Cumulative Days	Cumulative Days
0-6	0	0	0	0	0	0	0	0
6.1-12	14	32	14	32	17	39	17	39
12.1-18	30	68	44	100	27	61	44	100
18.1-24	....							
24.1-30	....							
30.1-36	....							
36.1-40	....							
Dry	....							

Table 2 - - Kinston silt loam Groundwater Data Table
January -June, 2000 (182 Days)
Dorey Park, Data Logger Well,# 1 & ~2

Well # 1				Percent	Well # 2			Percent
Depth Range (in.)	Number of Days	Percent Time	Cumulative Days	Cumulative~ Days	Number of Days	Percent Time	Cumulative Days.	Cumulative Days
0 - 6	66	44	66	44	90	60	90	60
6.1-12	40	27	106	71	12	8	102	68
12.1-18	31	21	137	91	16	11	118	79
18.1-24	....				20	13	138	92
24.1-30	....				10	7	148	99
30.1-36	....				2	1	150	100
36.1-40	....				0	0	150	--
Dry	13	9	150	100	0	0	150	-
Missing	32		182		32		182	

Number of Days column refers to the number of days the surface of the free water was present within the depth range.

Percentage of Time column refers to the percent of time the water was present within the

depth range.

Cumulative Days column refers to the total number of days the water was present within the depth range.

Percentage of Cumulative Days refers to the percent of total time the water was present within the depth range.

DRY corresponds to the number of readings (converted to days) where the monitoring well recorded no water in the hole.

Days in the column headings corresponds to the number of data logger readings within a depth range divided by the number (normally 2, 4 or 8) of data logger readings per day. -.

Table 3 - - Kinston silt loam Groundwater Data Table
July - December, 2000 (184 Days)
Dorey Park, Data Logger Well # 1 & #2

	Well # 1				Well # 2			
Depth Range (in.)	Number of Days	Percent Time	Cumulative Days	Percent Cumulative Days	Number of Days	Percent Time	Cumulative Days	Percent Cumulative Days
0-6	3	2	3	2	2	1	2	1
6.1-12	13	8	16	10	8	4	10	5
12.1-18	103	62	119	72	35	19	45	24
18.1-24	....				92	50	137	74
24.1-30	....				35	19	172	93
30.1-36	....				8	4	180	98
36.1-40	....				4	2	184	100
Dry	47	28	166	100	....			
Missin9	18		184					

Table 4 - - Kinston silt loam Groundwater Data Table
January- June, 2001 (181 Days)
Dorey Park, Data Logger Well # t &~2

	Well # 1				Well # 2			
Depth Range (in.)	Number of Days	Percent Time	Cumulative Days	Percent Cumulative Days	Number of Days	Percent Time	Cumulative Days	Percent Cumulative Days
0 - 6	34	19	34	19	73	40	73	40
6.1-12	87	48	121	67	39	21	112	62
12.1-18	60	33	181	100	32	18	144	80
18.1-24	....				33	18	177	98
24.1-30	....				4	2	181	100
30.1-36	....							
36.1-40	....							
Dry	....							

Number of Days column refers to the number of days the surface of the free water was present within the depth range.

Percentage of Time column refers to the percent of time the water was present within the depth range.

Cumulative Days column refers to the total number of days the water was present within the depth range.

Percentage of Cumulative Days refers to the percent of total time the water was present within the depth range.

DRY corresponds to the number of readings (converted to days) where the monitoring well

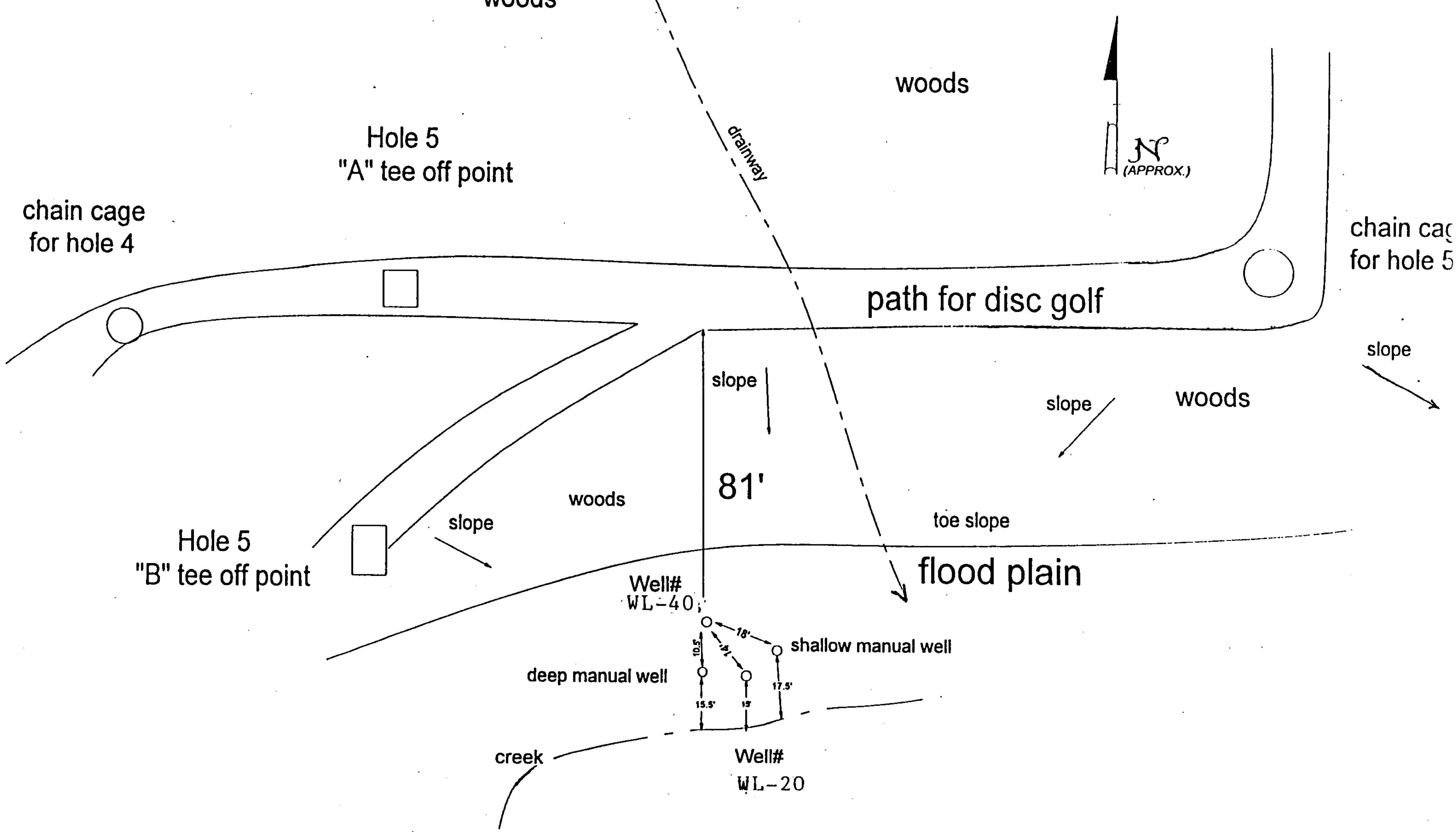
recorded no water in the hole.

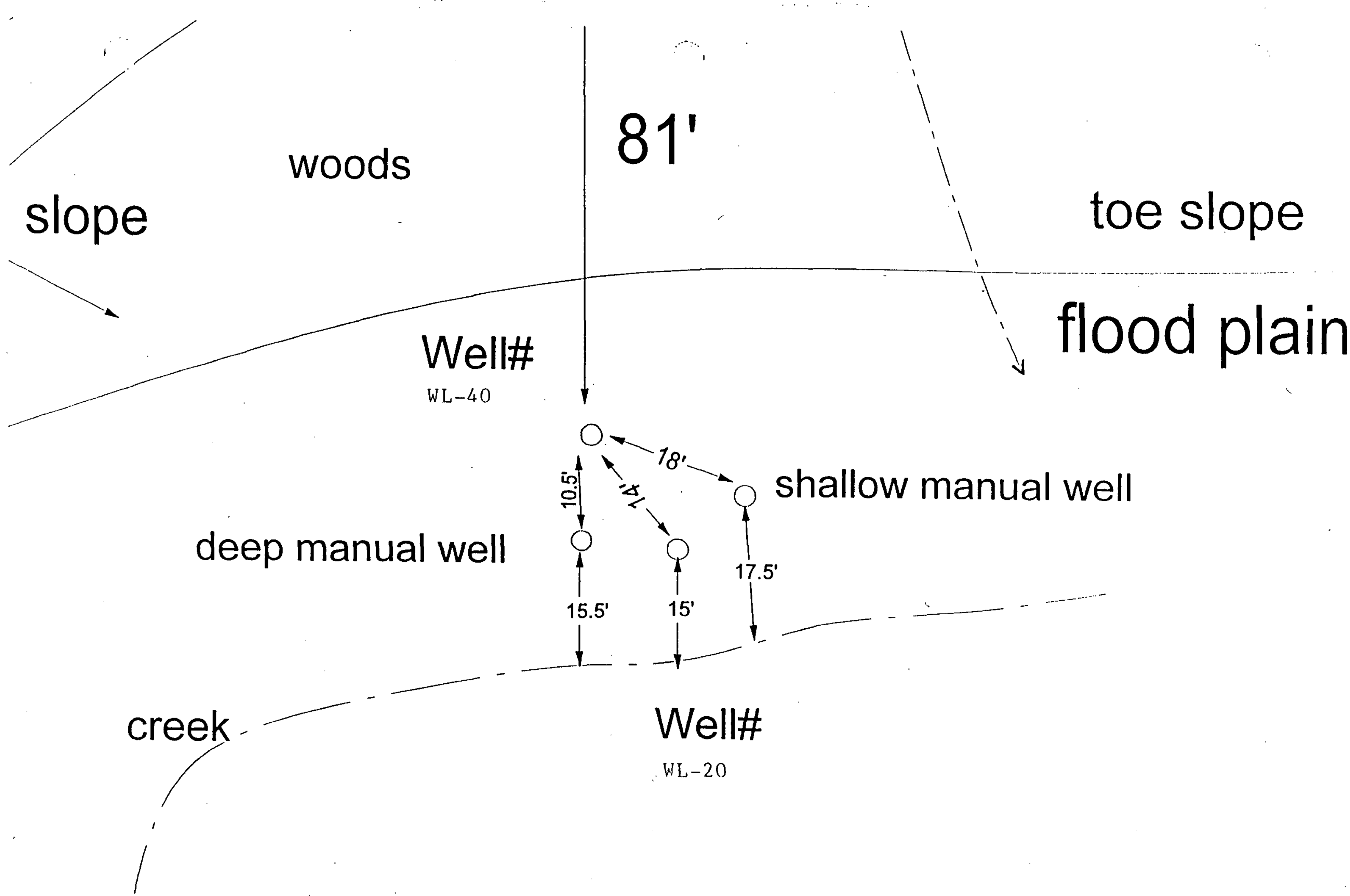
Days in the column headings corresponds to the number of data logger readings within a depth range divided by the number (normally 2, 4 or 8) of data logger readings per day.

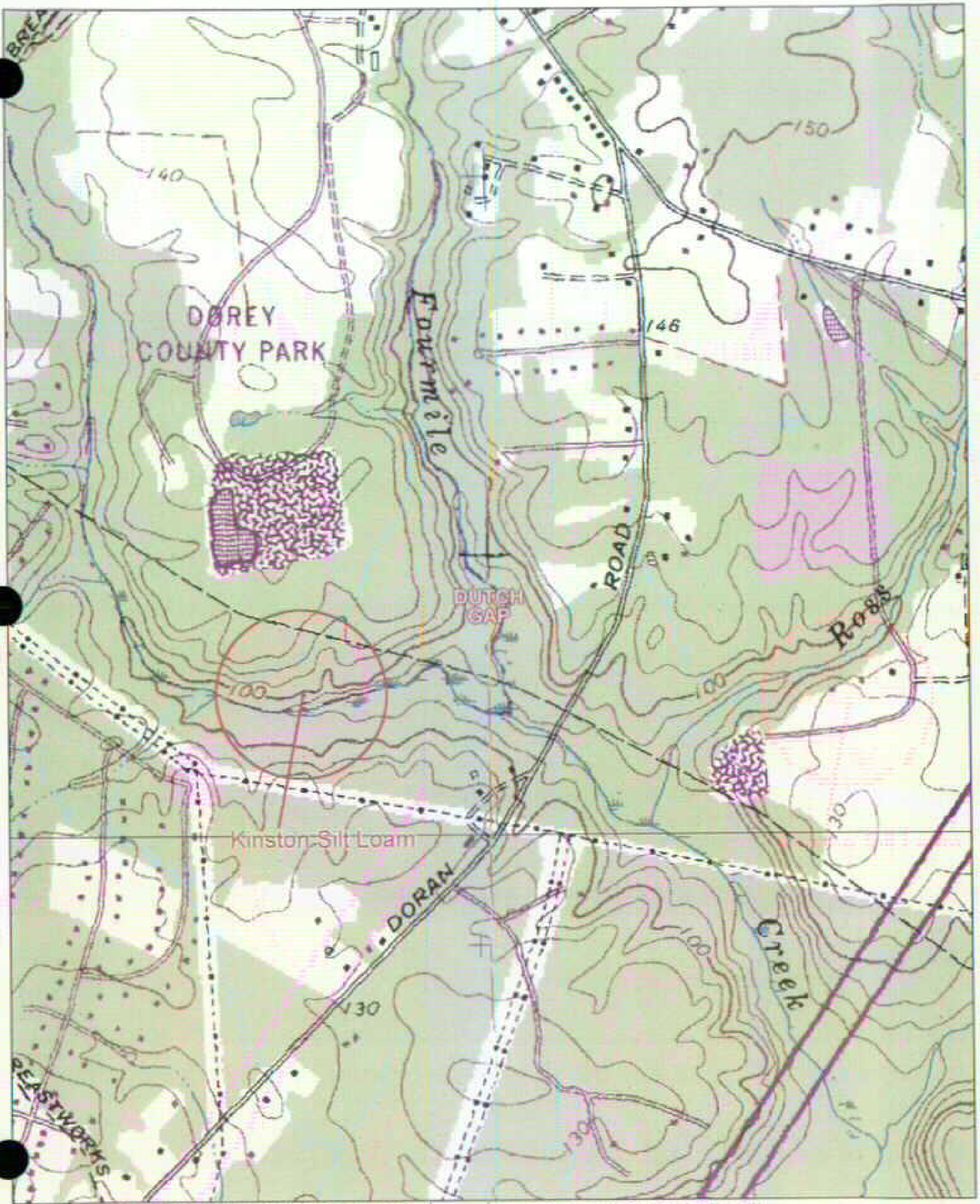
AUTOMATED versus MANUAL WATER' TABLE READINGS

Date	Well #1 Reading (in.)	Well #2 Reading (in.)	Deep Manual Well Reading (in.)
Nov 18.1999	-14.2	-15.7	-17.7
Dec 22.1999	-10.3	-9.6	-13
Jan 3 2000	-12.3	-11.8	-15.4
Feb 4 2000	-2.6	0	-7.4
Mar 13.2000	-5.7	-3.3	-10.7
Mar 31.2000	-3.8	-1.1	-8.3
.Apr 19,2000	-2.1	+1.8	-3.6
May 11,2000	-10.4	-9.6	-14.8
Jun 5,2000	-16.3	-20.5	-21.3
Jun 26,2000	-19.2	-30.4	-31.9
Jul 21,2000	-16.8	-20.5	-22.1
Aug 24,2000	-18.9	-27.1	-28.8
Sep 22,2000	-18	-21.9	-23.4
Oct 19,2000	-o	-24.3	-25.8
Nov 27,2000	-15.4	-19	-20.7
Jan 5,2001	-14.9	-17.3	-18.5
Mar 1,2001	-7.3	-4.6	-10.8
Apr 18,2001	-6.2	-3	-9.1
Jun 4,2001	-14.3	-17	~19.7
Jul 26,2001	-18.5	-38.3	-40

Dorey Park
Scale 1"=40'




81'
woods
slope
toe slope
flood plain
Well#
WL-40
18'
10.5'
14'
shallow manual well
deep manual well
17.5'
15.5'
15'
creek
Well#
WL-20



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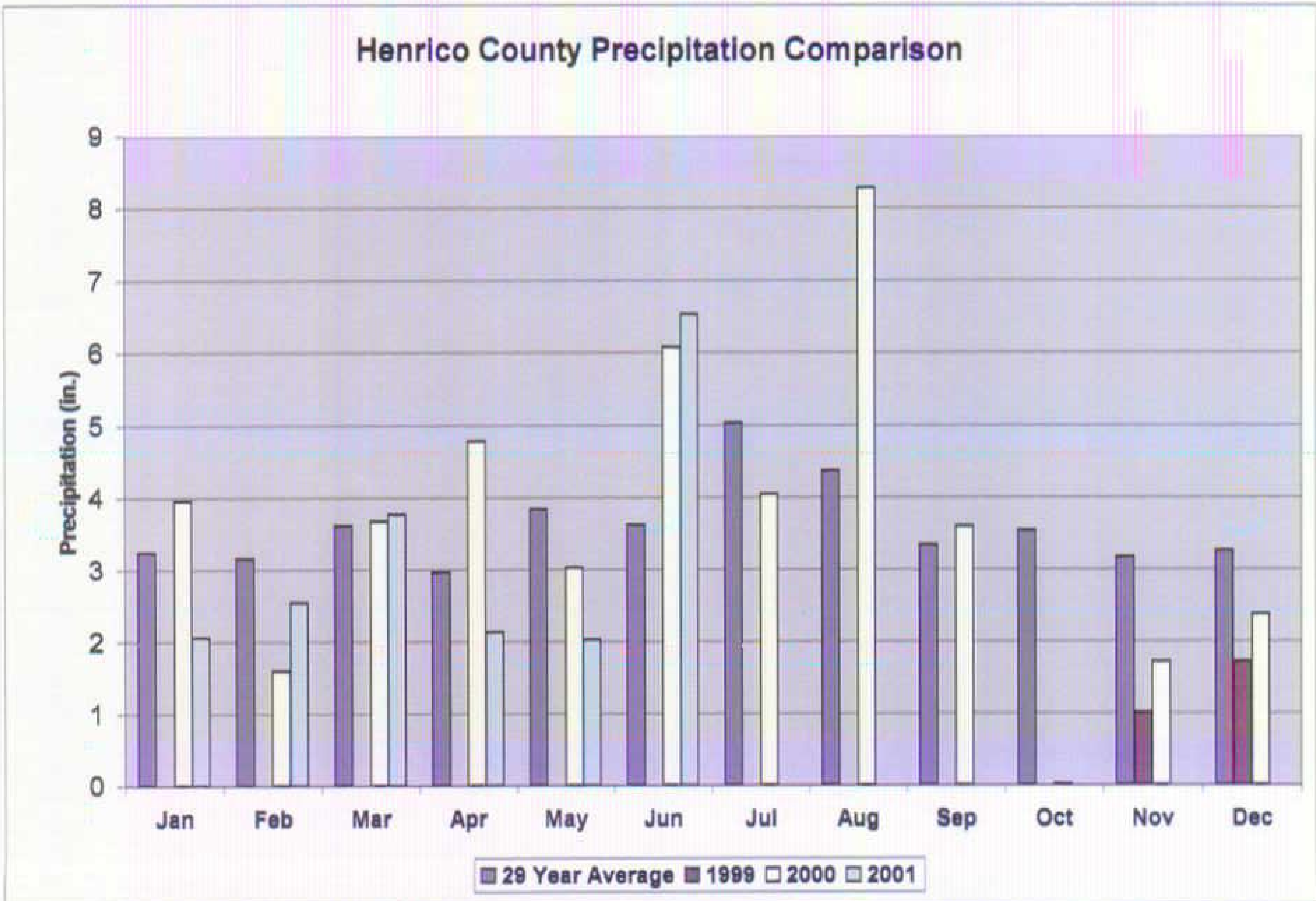
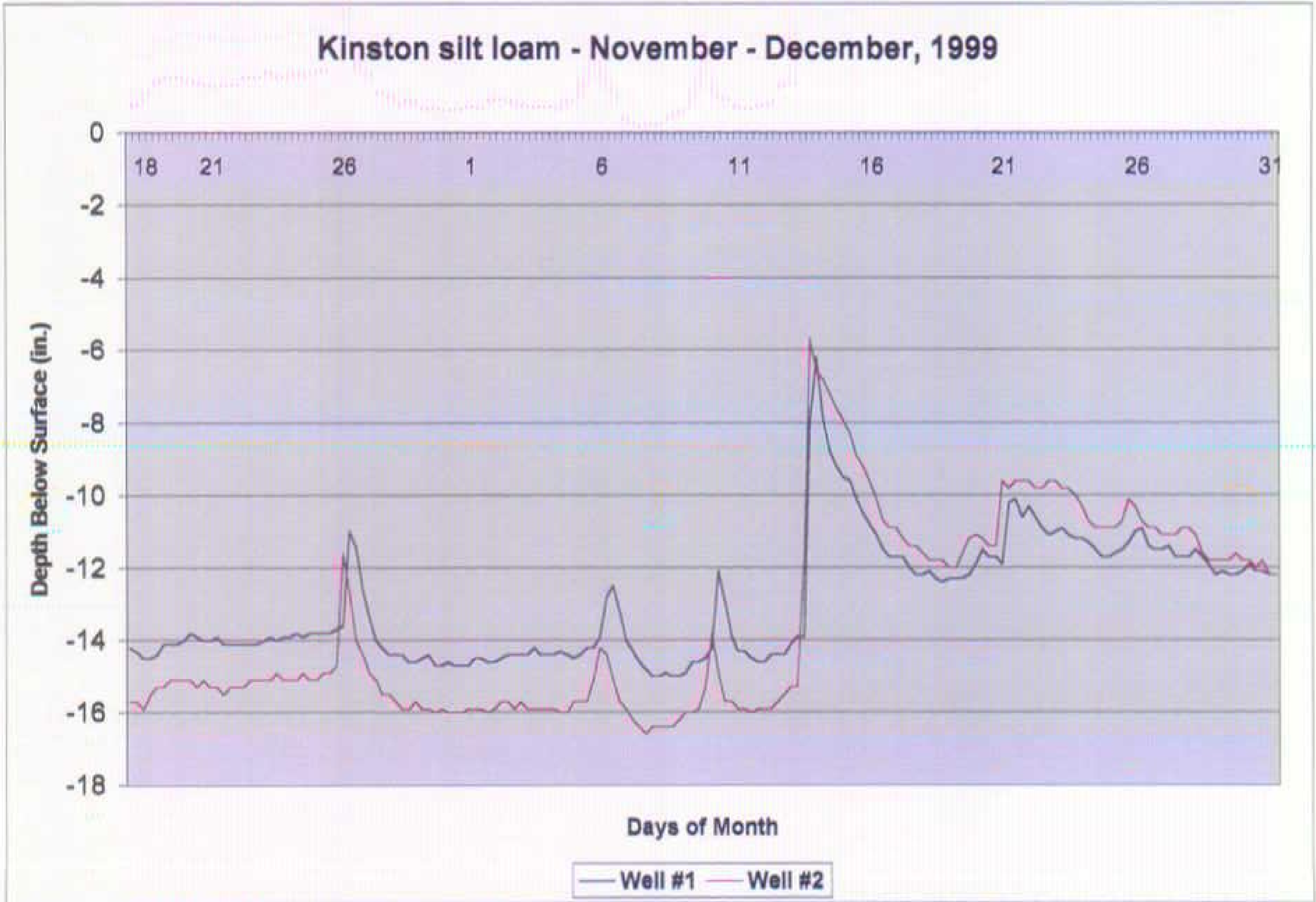
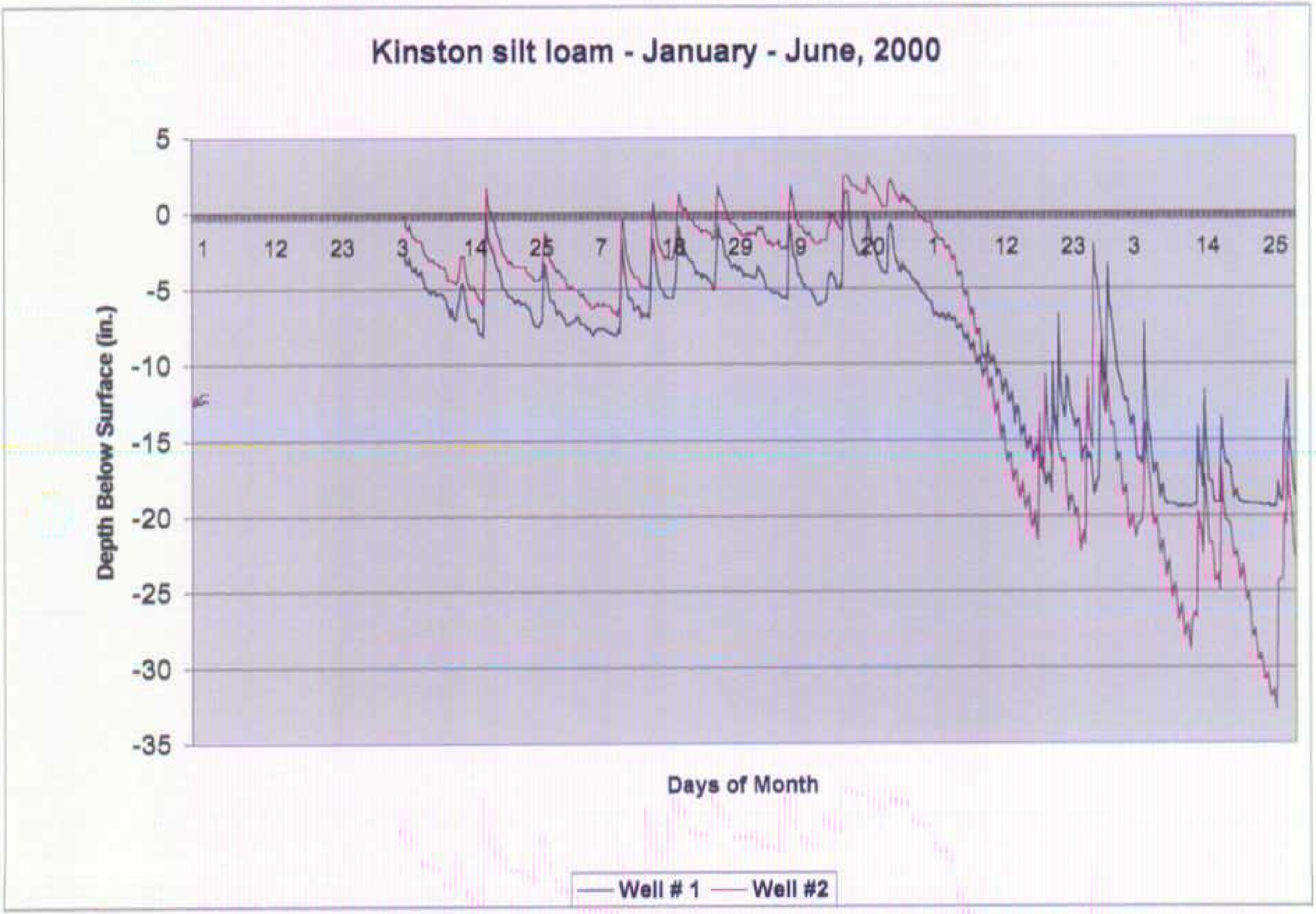
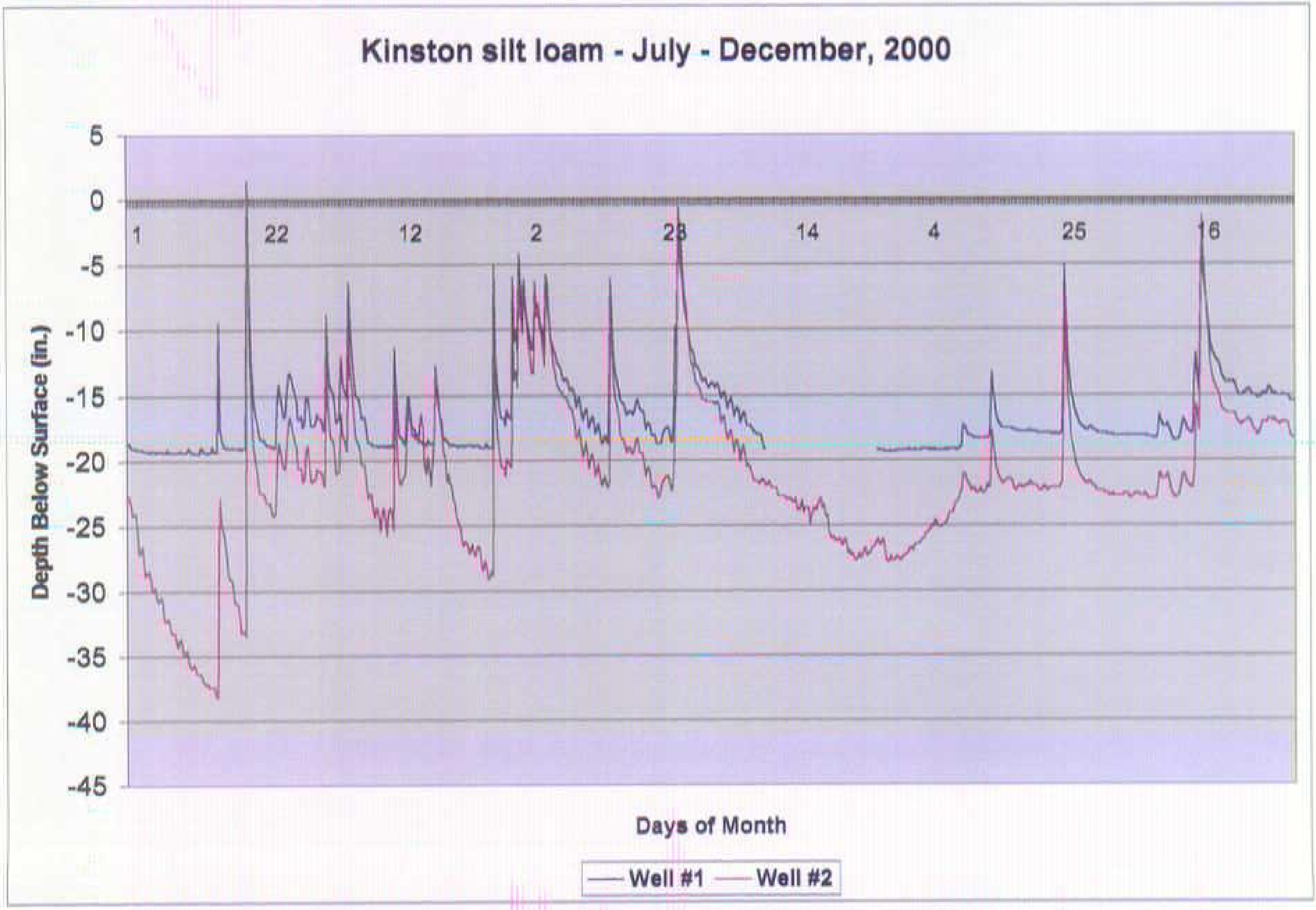

Henrico County Precipitation Comparison
Precipitation (in.)
9
8
7
6
5
4
3
2
1
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
29 Year Average
1999
2000
2001

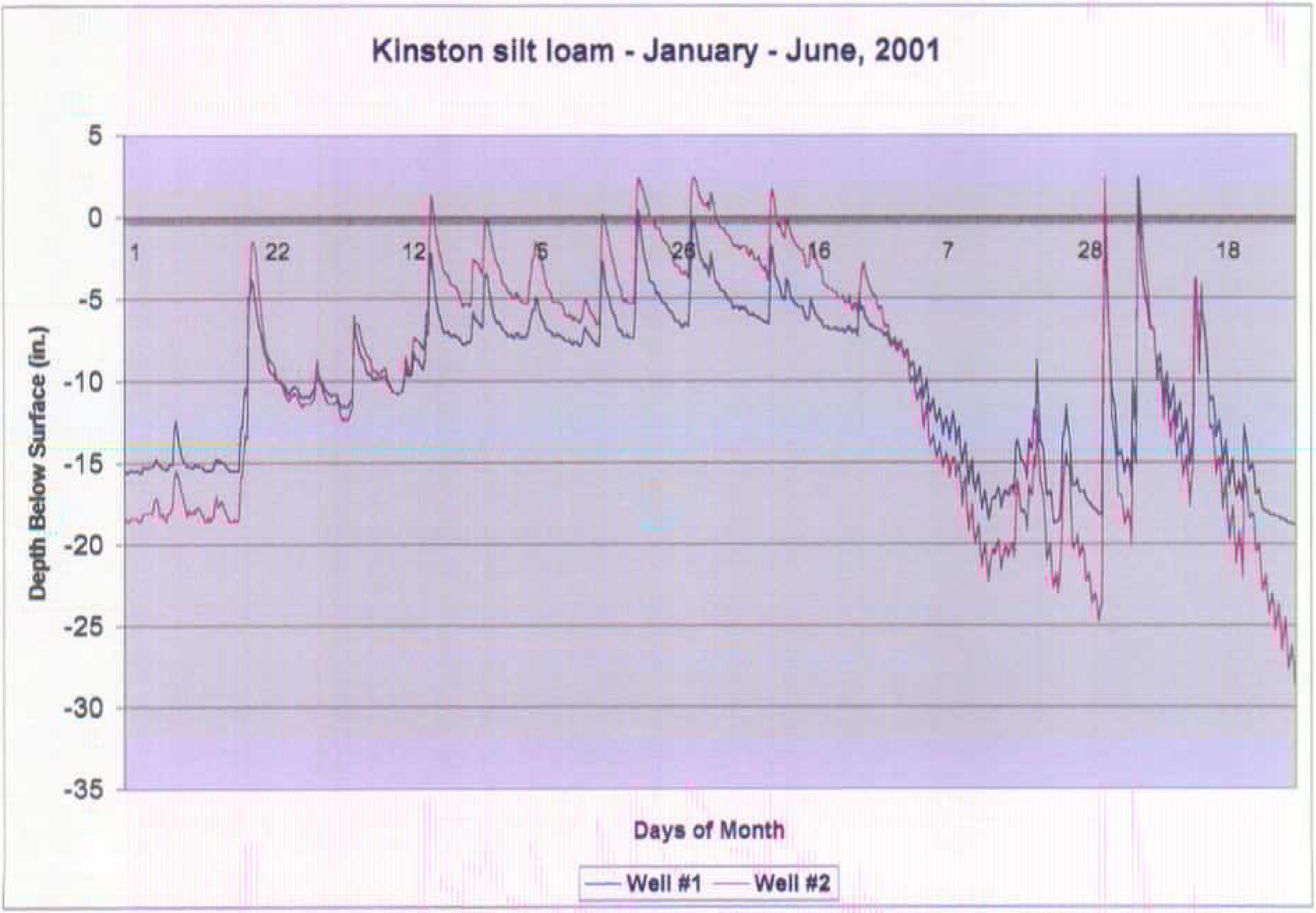


Kinston silt loam - November - December, 1999
Depth Below Surface (in.)
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
18
21
26
1
6
11
16
21
26
31
Days of Month
Well #1
Well #2



Kinston silt loam - January - June, 2000
5
0
-5
-10
-15
-20
-25
-30
-35
Depth Below Surface (in.)
1
12
23
3
14
25
7
18
29
9
20
1
12
23
3
14
25
Days of Month
Well # 1
Well #2


Kinston silt loam - July - December, 2000
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
Depth Below Surface (in.)
1
22
12
2
28
14
4
25
16
Days of Month
Well #1
Well #2



Kinston silt loam - January - June, 2001
Depth Below Surface (in.)
5
0
-5
-10
-15
-20
-25
-30
-35
1
22
12
5
26
16
7
28
18
Days of Month
Well #1
Well #2

SOIL EVALUATED: Leaksville silt loam

LOCATION:

This research site was located in the south central portion of Pittsylvania County, Virginia. Refer to the accompanying section of the U.S. Geologic Survey Brosville topographic map for the cultural and landscape features of the area. The topographic map section shows the general location of the automated WL-20 data logger well installed on this residential property.

RATIONALE FOR SITE SELECTION:

A failing drainfield lead to the selection of this site for the placement of a data logger well. The soil at this location was mapped as Leaksville silt loam. With the soil characteristics present, Leaksville soils do not meet the drainfield requirements of the Virginia Department of Health. The soil characteristics on this property do not meet those drainfield requirements and should not have been used as a site for an onsite system.

The resident at this site had expressed interest in purchasing the home if a suitable repair could be made. The cost of the repair would be added to the price of the home. My first site visit was to evaluate a suggested repair, which with poor siting, was to be installed over the top of the failing drain§eld. The term "failing drainfield" is used because effluent was ponding.on the surface behind the house:' VDOTwaS planning a road-widening project involving this property at the time of our visits. The limits of the road project were unknown at that time and at the time of the installation.

The interesting soil problem was the restrictive horizon near the soil surface. As part of the restriction, there was an abrupt textural change, from fine sandy loam to clay. My goal was to collect information that would enable the Virginia Department of Health or a private engineer to design a more appropriate system repair. The height of the water table and the length of time the water table was elevated would be critical to the design of a new septic system. Without that crucial information any repair would have a high .probability of failure.

SOIL AND SITE INFORMATION:

The soil at this site formed in residuum weathered from Triassic shale. Leaksville soils are found on broad summits around the heads of drains and intermittent drains. The data logger site was located on an upper sideslope. The well was installed in a small brushy area with some native grasses and weeds. The well was installed out of the edge of the front yard and camouflaged to deter vandalism.

The published soil survey, Soil Survey of Pittsylvania County and the City o__f Danville, Virginia, J.C. Nicholson et al., 1994, shows the research site as being mapped as Leaksville silt loam. Leaksville soils are poody drained. The soils at this site are somewhat poody drained to poody drained. An auger soil profile description was made at the site and is included. When compared to the official soil series description for the Leaksville series (refer to'the Appendix), the soil at this site falls outside the range of characteristics. That means the soil at the site was not representative of Leaksville soils, but was an inclusion. The Leaksville soils are shallow to a Cr horizon and have gleyed horizons from 6 to 24 inches.

The soil characteristics at this site preclude the installation of any onsite septic system. With the wetness indicators presen, a septic permit should not have been issued for this site years ago.

CLIMATIC DATA FOR THE SITE:

The site selected was less than 10 miles from the Danville Airport, where official NOAA weather data are collected, so precipitation data from the airport was used to evaluate rainfall during the study period. The data logger well was installed in February 2000. The precipitation comparison graph shows how rainfall totals for each month of 1999 and 2000 compares to the monthly 25-year average (1961-1990).

It is interesting to review the weather data for 1999, the year preceding the installation of the well. Only four of the twelve months had normal or above normal rainfall. In September, a 12.83-inch precipitation total was reached with the aid of a storm. With the 12.83-inch total compared to the average of 3.54 inches for the normal level of precipitation in September, the total for the year was 45.13 inches compared to the average 43.18 inches.

It is apparent that for the October-December 1999 period, precipitation was well below normal. In fact, rainfall was only 68% of the long-term average for that three month span. Therefore, the water table levels at the site would be expected to be shallower (nearer to the surface) during a fall with normal precipitation.

For the period January-May 2000, total precipitation was only 0.21 inches above the 25-year average. That means that the water table levels would be expected to be representative of normal conditions 'at the site.

For the period July-December 2000, monthly rainfall was 20 percent below normal. It is noteworthy that only 0.12 inches of rain was recorded for the entire month of October 2000, making it the driest October since rainfall data collection began at the Danville Airport. The October-December 2000 period was very dry.

In fact, rainfall was only 31% of the long-term average for that 3 month span. That dry fall situation was very similar to moisture conditions noted for October-December 1999. Therefore, the water table levels at the site would be expected to be shallower during a fall with normal precipitation. The dry period for the latter quarter of 1999 allowed the water table to be depressed entering into the new year. If the last quarter of 1999 had experienced normal precipitation the data logger would have recorded numerous readings at the 5-inch level.

Except for a few exceptional wet months, the overall precipitation situation was one of below normal to near drought conditions. It should be noted that the original project completion date was extended due to severe drought conditions in most of the state during 1999. Fall 2000 through spring 2001 was also well below normal. Therefore, the January-August 2000 period (excluding February) had near normal precipitation, while the rest of the study period had significantly below normal rainfall or was in the normally dry summer period.

RESULTS:

A WL-20 automated data logger well was installed on February 9,1999. There was continuous data collection from the starting date until August 2000. The 20-inch data logger well was withdrawn because the property was being bush hogged to prepare for the highway project. The operator of the tractor was preparing to drive over the well. He indicated that to his understanding the well location would be in the construction zone.

The Leaksville soil at this site had common light gray (10YR 7/1) mottles (or iron depletions) below 5 inches in the E horizon, indicating it was a poorly drained soil. Normally, it would be assumed the seasonal water table would be within the 5 to 11 inch E horizon during the wet winter months. With the numerous mottles present at shallow depths and extending to 58 inches, there was limited discussion as to the existing wetness characteristics as related to mottle color.

Mottles, including grays, were present in all of the horizons below the Ap. All of the mottled depth was included as part of the water table. The reds and browns were located at the same depths as the gray mottles. Moving down slope towards the lower edges of the sideslope, the Ap horizon began exhibiting mottles due to increasing wetness.

The dense, mottled Bt1 hodzon was restrictive, which was confirmed by the soil profile description remarks made for this site (i.e., the Bt1 was only moist, while free water rose in the borehole). Dudng the winter months, the deeper soil beneath the Bt hodzons was a pudding-like consistence from being saturated.

The water table hydrograph of February-August 2000 shows the presence of free water in the soil at a depth of 5-15 inches for the seven-month period. Near the end of the time period the water table level began dropping which is a normal response for the dry fall months. The hydrograph exhibits "spikes" or quick responses to rainfall events for the area. Yet one has to study the ten-inch depth line and see the presence of the water table for an extended time period.

The February; August, 2000 Groundwater Data Table shows that the surface of the free water surface was in the E hodzon for 114 days, or 62% of the time during this 184 day period. The free water surface was in the Bt1 horizon 59% of the time. During the seven-month period, the water table was almost always present in the E and Bt horizons. The data logger water table level corresponds to the shallowest depth or level of gray mottles in the soil.

The February-August, 2000 Groundwater Data Table showed that free water was in the Bt1 horizon about 174 days or 93% of the time during this 184-day period. The Bt1 covered the 11 to 20 inch depth range. Even the summer months had water present, which is unusual. Water tables normally drop during the dry hot summer. However, the abrupt textural change and the restrictive horizons held water closer to the soil surface even when the months were drier than normal. With soil surface slopes of 2 to 4% there would be little runoff during a storm event.

CONCLUSIONS!

This site had precipitation 'levels within normal ranges for the first six months of the study period. In spite of that, .there was free water present for significant periods of time during the winter, spring and summer months. In addition, the depth to free water was similar to the level where gray mottles were observed in the soil. Once the water table rose in the soil, it stayed up for an extended period of time.

Free water was observed in the E and Bt1 horizons only for extended periods of time, and was always associated with precipitous rises in the water table. For nearly the entire study period, free water was in these horizons (174 days) continuously. The soil morphologic features present related very well to the presence of water in the soil for the number of days observed. Under normal precipitation it would be expected that the seasonal water table would be in the.E and Bt1 horizons for similar periods of time. During the normal wet winter months the soil should be saturated almost to the surface.

The presence of mottles (redoximorphic features) clearly relates to the duration of soil wetness. The presence of multiple mottles throughout the profile indicate active processes of oxidation-reduction. With strong brown, yellowish red and red mottles present in the profile, the oxidation process is occurring. In the 40 to 44 inch depth range, a gleyed hodzon was present which indicates a strong reduction process. In the official Leaksville soil series, gleyed horizons are present from 6 inches to 24 inches.

The location of this site on a gently sloping sideslope, with a short upslope watershed, may have contributed to how wet the soil was. With gentle slopes, there would be limited amounts of runoff. As the precipitation soaks into the soil, it is perched or held up by the restrictive horizon. During the winter-spring' periods when plants were dormant and the evapotranspiration rate was very Iow, excess moisture not held in the soil would move very slowly downslope. The well was installed on the upper side of the sideslope. Moving lower on the sideslope position, plant characteristics indicating wetness were more numerous. For example in the edge of the woods at the back of the lot, the tree roots were on the surface. There was visible evidence of surface ponding of water in the woods.

As was noted earlier, this soil does not meet the minimum state requirements for a conventional gravity drainfield, based on soil morphology. Based on the seven-month monitoring period studied, it is apparent why the conventional septic system that had been installed failed. The gravel filled trenches (at a depth of 18 inches) were inundated with free water for long periods of time. Based on the state sewage regulations in effect when the permit was issued, an 18 inch zone of suitable soil beneath the gravel filled trenches would have been required (the "stand-off zone") for treatment and disposal of the wastewater. Based on this research, the seasonal water table would have been in the "stand-off zone" at least for 95% of the time during a winter-spring period. Soil morphology indicated this soil and site was not suitable for a conventional graVity drainfield. Seven months of monitoring data taken while there was below or near normal precipitation also showed the soil was unsuitable.

It is apparent the system on this lot is failing and repair options are very limited. The information from the data logger will aid in the design of any possible repair. This information suggests a high level of treatment would be required. There is a strong possibility the effluent will surface during the wetter periods due to the restrictive horizon and high water table.

Leaksville silt loam

Profile Well # 1 (WL20)

Ap--0 to 5 inches, yellowish brown' (10YR 5/4) sandy loam; very friable, nonsticky and nonplastic.

E--5 to 11 inches; mottled strong brown (7.SYR 5/6), light gray (10YR 7/1), yellowish brown (10YR 5/6), red (2.5YR 4/6) and pale brown (10YR 6/3) sandy loam; very friable, nonsticky and nonplastic.

Btl--11 to 20 inches; mottled strong brown (7.SYR 5/6), gray (10YR 6/1) and white (10YR 8/1)clay; pressure faces; very firm, sticky and plastic; common mica flakes; restrictive.

Bt2--20 to 28 inches; mottled strong brown (7.SYR 5/6), brown (7.SYR 5/2), light gray (10YR 6/1), white (10YR 8/1) and yellowish red (SYR 5/6) clay;~ pressure faces; exceedingly firm, very sticky and very plastic; common mica flakes; restrictive.

Bt3--28 to 39 inches; mottled light gray (10YR 7/1), reddish yellow (7.5 YR 7/6), brown (7.5YR 4/3), pinkish gray (7.5 YR 7/2), dusky red (2.5YR 4/4) and strong brown (7.5YR 5/4) clay; manganese stains on peds; material comes from the bucket in large chunks; pressure faces, exceedingly firm, very sticky and very plastic; many fine mica flakes; restrictive.

BCgl--39 to 44 inches; mottled light gray (10YR 7/1), gray (7.5YR 6/1), yellowish red (5YR 5/6), light brownish gray (10YR 6/2) and strong brown (7.5 YR 5/4) clay; exceedingly firm, very sticky and very plastic; many fine flakes of mica; restrictive.

BC--44 to 49 inches; mottled weak red (2.5YR 6/2), pale red (2.5YR 7/3), yellowish red (5YR 5/6), and very pale brown (10YR 8/4) silty clay loam; dry, very firm, slightly plastic and slightly plastic; common very fine mica flakes, restrictive; auger grinding.

C--49 to 58 inches; mottled pale red (2.5YR 7/3), dusky red (2.5YR 3/2), light brownish gray (10YR 6/2), reddish yellow (7.5YR 6/8) and reddish gray (2.5YR 7/1), sandy loam; dry, hard, nonsticky and nonplastic; common very fine mica flakes; restrictive.

Remarks: This profile taken from an auger hole in field with small pines growing.

The upper foot of the profile was wet while the soil horizons below the restriction were moist during a summer boring. Soil horizons during the winter were saturated with some of the horizons being like pudding with few notable or observable characteristics.

Table I - - Leaksville silt loam Groundwater Data Table
February-August, 2000 (184Days)
Bachelors Hall, Data Logger Well # 1

Well # 1

Depth Range (in.)	Number Of Days	Percent Time._~____	Cumulative Days	Percent Cumulative Days
0-6	9 -	5	9	5
6.1-12	114	62	123	67
12.1-18	59	32	182	98
18.1-20	2	1	184	1

Number of Days column refers to the number of days the surface of the free water was present within the depth range.

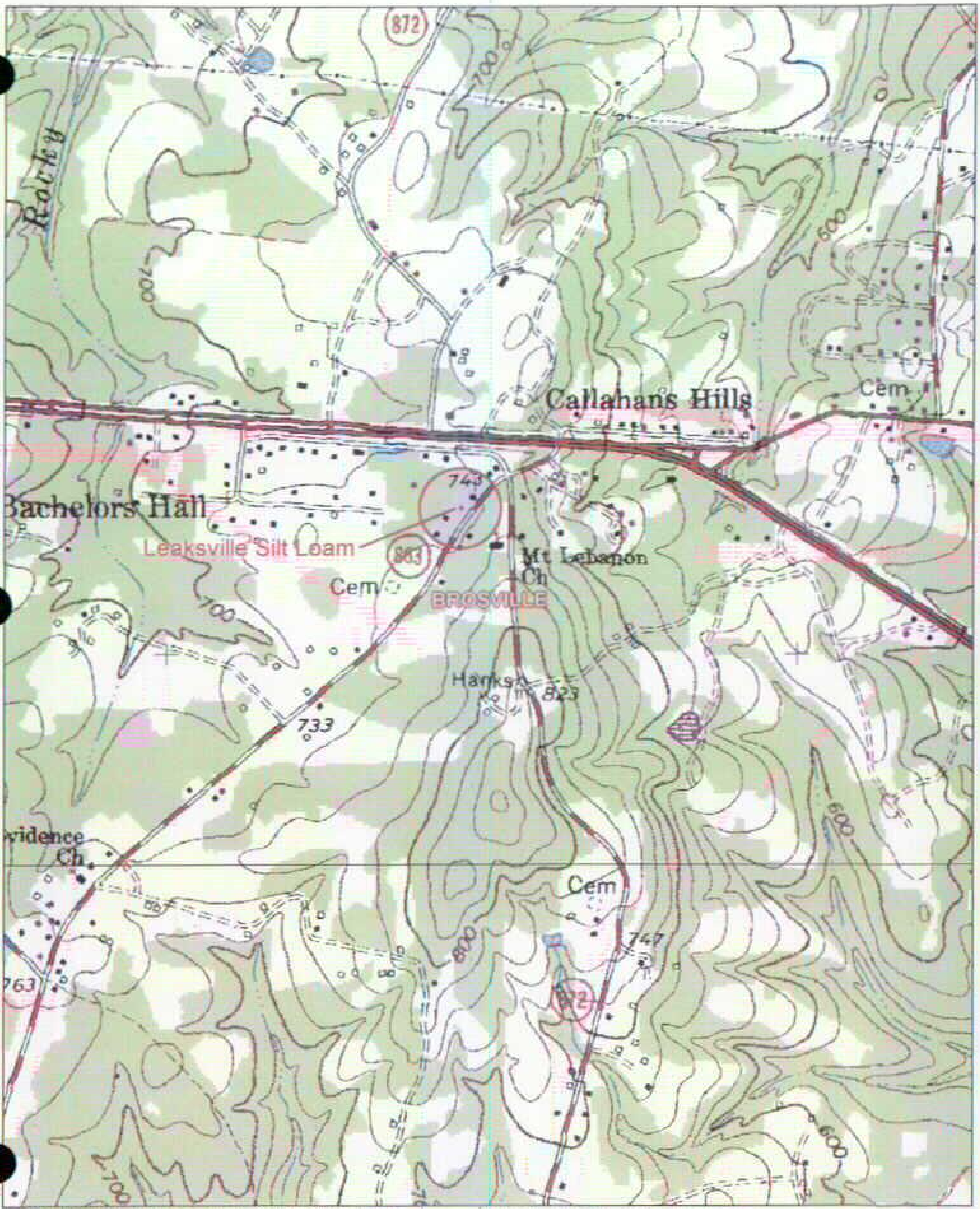
Percentage of Time column refers to the percent of time the water was present within the depth range.

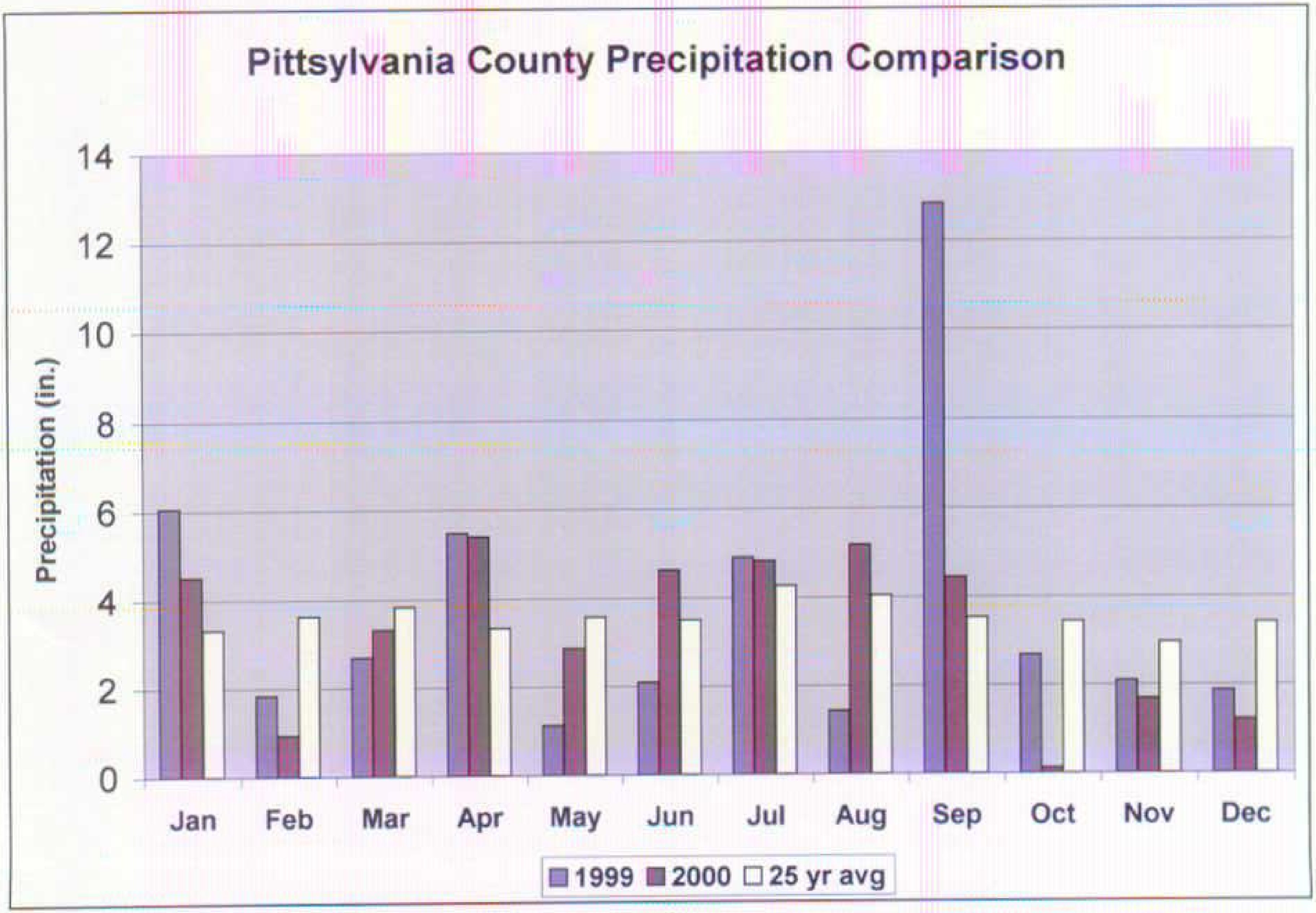
Cumulative Days column refers to the total number of days the water was present within the depth range.

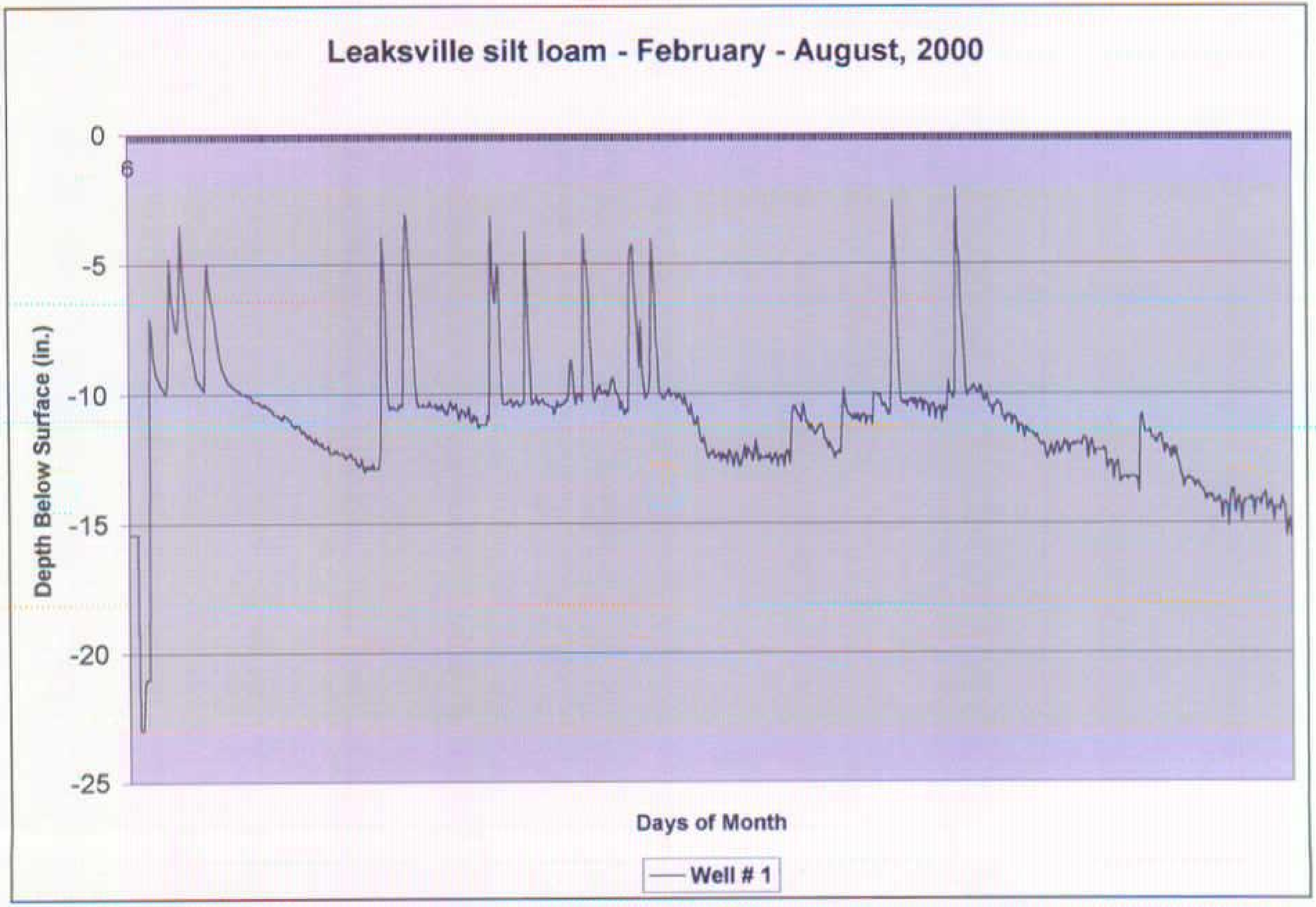
Percentage of Cumulative Days refers to the percent of total time the water was present within the depth range.

DRY corresponds to the number of readings (converted to days) where the monitoring well recorded no water in the hole.

Days in the column headings corresponds to the number of data logger readings within a depth range divided by the number (normally 2, 4 or 8) of data logger readings per day.


872
Rocky
700
600
Callahans Hills
Cem
Bachelors Hall
743
Leaksville Silt Loam
863
Mt Lebanon
Ch
Cem
BROSVILLE
Hanks
823
733
Providence
Ch.
Cem
747
800
763
872
600


Pittsylvania County Precipitation Comparison
Precipitation (in.)
14
12
10
8
6
4
2
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
1999
2000
25 yr avg


Leaksville silt loam - February - August, 2000
0
-5
-10
-15
-20
-25
6
Depth Below Surface (in.)
Days of Month
Well # 1

SOIL EVALUATED: Lenoir silt loam

LOCATION:

This research site was located in the northern portion of Westmoreland County, Virginia. Refer to the accompanying portion of the Kinsale U.S. Geologic Survey toPographic map for the general character of the area. The accompanying detailed site sketch shows the location of two automated WL-20 data loggers on this residential property.

RATIONALE FOR SITE SELECTION:

There were several reasons for using this site. First, the type of soil at the site', Lenoir, represents a major soil type located over large areas in the state. To study it would provide valuable information that could apply to numerous sites considered for onsite septic systems. Second, while the Lenoir soil does not meet Virginia criteria to allow installation of a conventional gravity drainfield, an alternative type system was experimentally permitted to provide a system for an existing home. And finally, the residence at this site employs an alternative onsite waStewater disposal system, so a water table study would provide information on how well this alternative septic system works in problem soils.

SOIL AND SITE INFORMATION:

The soil at this site formed in very fine textured, stratified, unconsolidated, fluvio-marine sediments of the lower and middle Coastal Plain. There was a long, level to nearly level fiat that lies adjacent to the site. The site was also on a level to nearly level fiat, near a small drainageway. The wells were located in the yard, vegetated with fescue-type lawn grasses. Well # 1 was located in the footprint of the Puraflo pad and Well # 2 was located 110 feet away.

The published Soil Survey of Westmoreland County, VirQinia, John C. Nicholson, et. al., August 1981, shows the research site as being mapped as Lenoir silt loam (9). Lenoir is a somewhat poorly drained soil.

A detailed soil profile description was made at the site and is included. When compared to the official soil series description for the Lenoir series (refer to the Appendix), the soil at this site falls within the range of characteristics. That means the soil was typical or representative of Lenoir soils.

Since the soil was unsuitable for a conventional gravity drainfield, a Puraflo (peat moss) Biofilter system was permitted due to its reduced area requirements and experimental status. The 6 inches of 3/4-1 inch diameter clean gravel was installed at grade, the modules set on the gravel pad, pipes connected and then soil backfill material used to level and landscape the site;'

CLIMATIC DATA FOR THE SITE:

The site was approximately 20 miles from the Colonial Beach Municipal Center, where official weather data are collected. Precipitation data from the municipal center was used to evaluate rainfall during the study period. The precipitation comparison graph shows how each month's rainfall total compares to the monthly 51-year average (1950-2001).

1999 was drier than normal except for a six week period. Hurricanes. Dennis, Floyd and Irene produced rainfall totals in excess of 10 inches during a six week period from September 3 through October 18. For the January-June period, precipitation was slightly below normal with 0.43 inches short or 97%. For the July-December period, precipitation was also below normal. In fact, rainfall was 96% of the long-term average for that period. Therefore, the water table levels at the site would be expected to be normal.

For the period January-June 2000, total precipitation was 7.3 inches above the 51-year average or 146%. That means that the water table levels would be expected to be above normal at the site.

For the period July-December 2000, monthly rainfall was above normal. Precipitation was 4.25 inches above the 51-year average or 121%. That means that the water table levels would be expected to be above normal at the site.

For the period January-June 2001, total precipitation was 8.52 inches above the 51-year average or 154%. That means that the water table levels would be expected to be above normal at the site.

Fourteen of the thirty months (March, September and October 1999, January, March, April, May, June, July, September and December 2000, and March, May and June 2001) had precipitation levels above normal. For the entire study period of January 1999 through June 2001, overall precipitation was 18.76 inches above the 51-year average or 122%. Water table levels would be expected to be above normal at the site.

RESULTS:

Two automated data loggers were installed at the site on February 23,1999. Wells were installed in the same soil, same landscape position and at the same topographic elevation. Well # I was installed within the footprint of an operating Puraflo wastewater system and Well # 2 was installed 110 feet away. Well # 2 was representative of the soil conditions at the Puraflo (peat moss) Biofilter system site but was remote enough to be unaffected by the wastewater system. Due to operator error, Well # 2 was not programmed properly and the collection of water table data did not commence until March 14,1999. There was continuous data collection from the starting date until June 30, 2001 for Well # 1 and March 8, 2000 for Well # 2. Well # 2 showed problems with taking alarms on. September 22, 1999 and also missed alarms on two separate occasions during November and December of 1999. Well # 2 stopped taking alarms and did not function after March 8, 2000.

The Lenoir soil at this site had a mottled matrix of light gray (10YR 7/1) (or iron depletions), light olive brown (2.5Y 5/4) and brownish yellow (10YR 6/6) in the Btg hodzon at 12-18 inches and continuing down below 24 inches, making it a poorly drained soil. Btg horizons start at 30 inches with a Cg horizon at 43 inches. This soil normally has a perched water table.

The water table hydrograph of March - June, 1999 shows the presence of free water in the soil within 6 inches for 29 days, 6-12 inches for 58 days, 12-18 inches for 98 days, 18-20 inches for 152 days and dry for 30 days. Rainfall for this period was above average or 23.1 inches. January, March, April, May and June were above normal while only February had below normal precipitation.

The March - June, 1999 Groundwater Data Table shows that the surface of the free water for Well # I was in the Ap horizon 29-98 days or 16-54% of the time during this 125 day period and in the Btg horizon 152 days or 84% of the time. The Btg horizon below 20 inches was dry for 30 days or 16% of the time. Well # 2 shows that the surface of the free water was in the Ap horizon 5-18 days or 4-14% of the time during this 125 day period and in the Btg horizon 38-48 days or 30~38% .~of~.thetime._The~Btg. horizon., below. 20 inches was dry for 77 days or 62% of the time.

The water table hydrograph of July - December, 1999 shows the presence of free water in the soil within 6 inches for 36 days, 6-12 inches for 44 days, 12-18 inches for 90 days, 18-20 inches for 159 days and dry for 25 days. Rainfall for this period was above average or 24.17 inches. July, September and December were above normal while August, October and November had below normal precipitation. October had only 0.04 inches.

The July - December, 1999 Groundwater Data Table shows that the surface of the free water for Well # I was in the Ap horizon 36-90 days or 20-49% of the time during this 184 day period and in the Btg horizon 169 days or 94% of the time. The Btg horizon below 20 inches was dry for 68 days or 37% of the time. Well # 2 shows that the surface of the free water was in the Ap horizon 2-3 days or 1-2% of the time during this 163 day period and in the Btg horizon 78-130 days or 48-80% of the time. The Btg horizon below 20 inches was dry for 33 days or 20% of the time.

The water table hydrograph of January - June, 2000 shows the presence of free water in the soil within 6 inches for 29 days, 6-12 inches for 58 days, 12-18 inches for 98 days, 18-20 inches for 152 days and dry for 30 days. Rainfall for this period was above average or 23.1 inches. January, March, April, May and June were above normal while only February had below normal precipitation.

The January - June, 2000 Groundwater Data Table shows that the surface of the free water for Well # 1 was in the Ap horizon 29-98 days or 16-54% of the time during this 182 day period and in the Btg horizon 152 days or 84% of the time. The Btg hodzon below 20 inches was dry for 30 days or 16% of the time. Well # 2 shows that the surface of the free water was in the Ap horizon 13-28 days or 19-41% of the time during this 68 day period and in the Btg horizon 44-50 days or 65-74% of the time. The Btg horizon below 20 inches was dry for 18 days or 26% of the time.

The water table hydrograph of July - December, 2000 shows the presence of free water in the soil within 6 inches for 36 days, 6-12 inches for 44 days, 12-18 inches for 90 days, 18-20 inches for 159 days and dry for 25 days. Rainfall for this period was above average or 24.17 inches. July, September and December were above normal while August, October and November had below normal precipitation. October had only 0.04 inches.

The July - December, 2000 Groundwater Data Table shows that the surface of · the free water for Well # I was in the Ap horizon 36-44 days or 20-24% of the time during this 184 day period and in the Btg horizon 90-159 days or 49-86% of the time. The Btg horizon below 20 inches was dry for 25 days or 13% of the time

The water table hydrograph of January - June, 2001 shows the presence of free water in the soil within 6 inches for 35 days, 6-12 inches for 69 days, 12-18 inches for 101 days, 18-20 inches for 169 days and dry for 11 days. Rainfall for this period was above average or 24.32 inches. March, May and June were above normal while January, February and April had below normal precipitation.

The January - June, 2001 Groundwater Data Table shows that the surface of the free water for Well # I was in the Ap horizon 35-69 days or 20-39% of the time during this 181 day period and in the Btg horizon 101-169 days or 56-94% of the time. The Btg horizon below 20 inches was dry for 11 days or 6% of the time.

CONCLUSIONS:

This site had precipitation levels dramatically above normal for 14 months of the 29 months the study was conducted. Those fourteen months, March, September and October, 1999; January, March, April, May, June, July, September and December, 2000; and March, April, and June, 2001; had totals of 73.53 inches, 27.54 inches above normal. That relates to 160% of normal precipitation for the fourteen months. ,The total study period (29 months) had 103.49 inches. Based on the 51-year average, this relates to 109% of normal precipitation.

In spite of near normal precipitation, free water was present for signifiCant pedods of time during the study period. In addition, the depth to free water was much shallower than where gray mottles were found in the soil. Once the water table rose in the soil, it remained for an extended period of time.

Free water was observed in the Ap horizon for fairly long periods of time and was always associated with precipitous rises in the water table. For the entire study period, free water was in this horizon for 20 to 323 days of the total 856 days or 6 to 38 percent of the time, though not continuously. There were no soil morphological features that could be related to the presence of water in the soil for the number of days observed.

Free water was observed in the Btg horizon for 160 to 642 days of the total 856 days during the entire study period and was always associated with sharp rises in the water table. This relates to 45 to 75 percent of the time. Light gray (10YR 7/1), light olive brown (2.5Y 5/4) and.brownish yellow (10YR 6/6) mottles in a mottled horizon were soil morphological features that could be related to the presence of water in the soil for the number of days observed.

The presence of light gray (10YR 7/1), light olive brown (2.5Y 5/4) and brownish yellow (10YR 6/6) redoximorphic features (mottles) in a gleyed horizon were soil morphologic features that could be related to the presence of water in the soil for extended periods of time. During the winter-spring time of the year, the seasonal water table, was. present in the Btg. horizon for, 6/10. to.,91;I 0. of. the,time.

As was noted earlier, this soil exceeded the minimum state requirements for a conventional gravity drainfield based on soil morphology. Based on the period studied, it is apparent that if a conventional septic system had been installed, the gravel filled trenches (at a depth of 18 inches) would have been inundated with free water for extended periods of time. Based on the state sewage regulations in effect when the permit was issued, an 18-inch zone of suitable soil beneath the gravel filled trenches would have been required (the "stand-off zone") for treatment and disposal of the wastewater. Although soil morphology indicated this soil was unsuitable for a conventional gravity drainfield, the monitoring data taken while there was above normal precipitation showed the soil was unsuitable.

Since the soil was unsuitable for a conventional gravity drainfield, a Puraflo (peat moss) Biofilter system had been installed at the site. Based on the state sewage regulations in effect when the permit was issued, a 12-inch zone of suitable soil beneath the soil surface would have been required (the "stand-off zone") for treatment and disposal of the wastewatero Based on this research, the seasonal water table would have been in the "stand-off zone" at least 36% of the time during a winter-spring period.

Lenoir silt loam

Profile for Well # 1: (WL20)

Ap--0 to 18 inches, dark grayish brown (10YR 54~2) silt loam; weak coarse granular structure; friable, slightly sticky, slightly plastic.

Btg--18 to 24 inches, mottled light gray (10YR 7/1), light olive brown (2.5Y 5/4) and brownish yellow (10YR 6/6) silt loam; weak medium subangular blocky structure; friable, slightly sticky, slightly plastic.

Remarks: This profile taken from an auger hole.

Profile for Well # 2: (WL20)

Ap--0 to 12 inches, dark grayish brown (10YR 54/2) silt loam; weak coarse granular structure; fdable, slightly sticky, slightly plastic.

Btg--12 to 24 inches, mottled light gray (10YR 7/1), light olive brown (2.5Y 5/4) and brownish yellow (10YR 6~6) silt loam; weak medium subangular blocky structure; friable, slightly sticky, slightly plastic.

Remarks: This profile taken from an auger hole.

Table I - - Lenoir silt loam Groundwater Data Table
February-June, 1999 (125 Days)

	Well # 1				Well # 2			
Depth Range (in.)	Number of Days	Percent Time	Percent Cumulative Days	Cumulative Days	Number of Days	Percent Time	Percent Cumulative Days	Cumulative i Days
0-6	3	2	3	2	5	4	5	4
6.1-12	11	9	14	11	13	10	18	14
12.1-18	16	13	30	24	20	16	38	30
18.1-20	16	13	46	37	10	8	48	38
Dry	79	63	125	100	77	62	125	100

Table 2 - - Lenior silt loam Groundwater Data Table
July-December, 1999 (184Days)

	Well # 1				Well #2			
Depth Range (in.)	Number of Days	Percent Time	Percent Cumulative Days	Cumulative Days	Number of Days	Percent Time	Percent Cumulative Days	Cumulative Days
0-6	2	1	2	1	2	1	2	1
6.1-12	1	1	3	2	1	1	3	2
12.1o18	I	1	4	2	75	46	78	48
18.1 °20	112	60	, 116	63	52	32	130	80
Dry	68	37	184	1 O0	33	20	163	1 O0

Number of Days column refers to the number of days the surface of the free water was present within the depth range.
Pementage of Time column refers to the percent of time the water was present within the depth range.
Cumulative Days column refers to the total number of days the water was present within the depth range.
Percentage of Cumulative Days refers to the percent of total time the water was present within the depth range.
DRY corresponds to the number of readings (converted to days) where the monitoring well recorded no water in the hole.
Days in the column headings corresponds to the number of data logger readings within a depth range divided by the number (normally 2, 4 or 8) of data logger readings per day.

Table 3 - - Lenoir silt loam Groundwater Data Table
January-June, 2000 (182 Days)

	Well # 1				Well # 2			
			Percent			Percent		
Depth Range (in.)	Number of Days	Percent Time	Cumulative Days	Cumulative Days	Number of Days	Percent Time	Cumulative Days	Cumulative Days
0 - 6	29	16	29	16	13	19	13	19
6.1-12	29	16	58	32	15	22	28	41
12.1-18	40	22	98	54	16	24	44	65
18.1-20	54	30	152	84	6	9	50	74
Dry	30	16	182	100	18	26	68	100

Table 4 - - Lenoir silt loam Groundwater Data Table
July-December, 2000 (184Days)

	Well # 1				Well # 2			
			Percent			Percent		
Depth Range (in.)	Number of Days	Percent Time	Cumulative Days	Cumulative Days	Number of Days	Percent Time	Cumulative Days	Cumulative Days
0 - 6	36	2O	36	2O				
6.1-12	8	5	44	24				
12.1-18	46	25	90	49				
18.1-20	69	37	159	86				
Dry	25	13	184	100				

Number of Days column refers to the number of days the surface of the free water was present within the depth range.

Percentage of Time column refers to the percent of time the water was present within the depth range.

Cumulative Days column refers to the total number of days the water was present within the depth range.

Percentage of Cumulative Days refers to the percent of total time the water was present within the depth range.

DRY corresponds to the number of readings (converted to days) where the monitoring well recorded no water in the hole.

Days in the column headings corresponds to the number of data logger readings within a depth range divided by the number (normally 2, 4 or 8) of data logger readings per day.

Table 5 - - Lenoir silt loam Groundwater Data Table
January-June, 2001 (181 Days)

	Well # 1				Well # 2			
			Percent			Percent		
Depth Range (in.)	Number of Days	Percent Time	Cumulative Days	Cumulative Days	Number of Days	Percent Time	Cumulative Days	Cumulative Days
0 - 6	36	20	35	20				
6,1-12	34	19	69	39				
12.1-18	32	18	101	56				
18.1-20	68	37	169	94				
Dry	11	6	181	100				

Number of Days column refers to the number of days the surface of the free water was present within the depth range.

Percentage of Time column refers to the percent of time the water was present within the depth range.

Cumulative Days column refers to the total number of days the water was present within the depth range.

Percentage of Cumulative Days refers to the percent of total time the water was present within the depth range.

DRY corresponds to the number of readings (converted to days) where the monitoring well recorded no water in the hole.

Days in the column headings corresponds to the number of data logger readings within a depth range divided by the number (normally 2, 4 or 8) of data logger readings per day.

Westmoreland County
Lenoir Silt Loam
Scale: 1"= 30

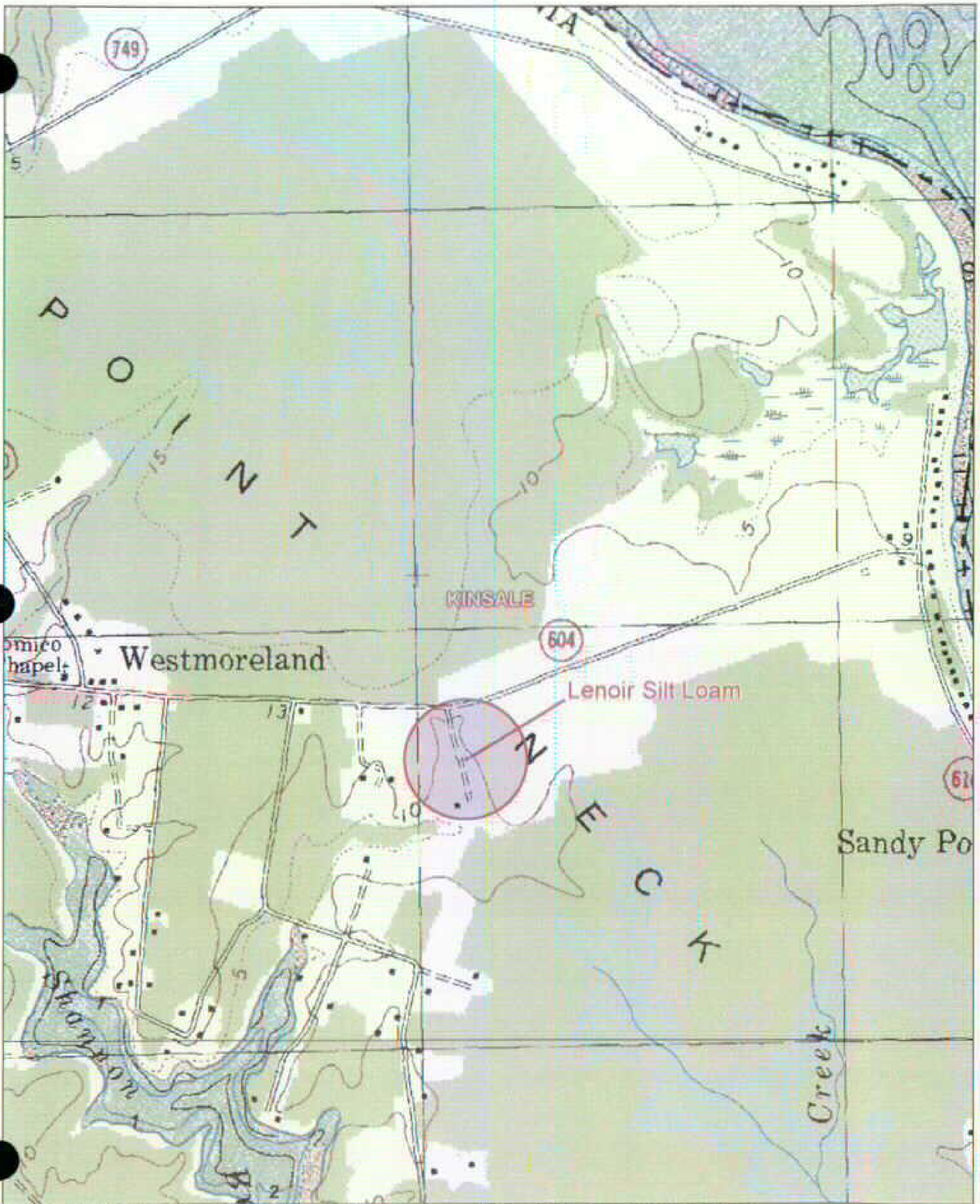
Data Logger #2 WL-40 ~

40'
20' x 90'
Puraflo Pad

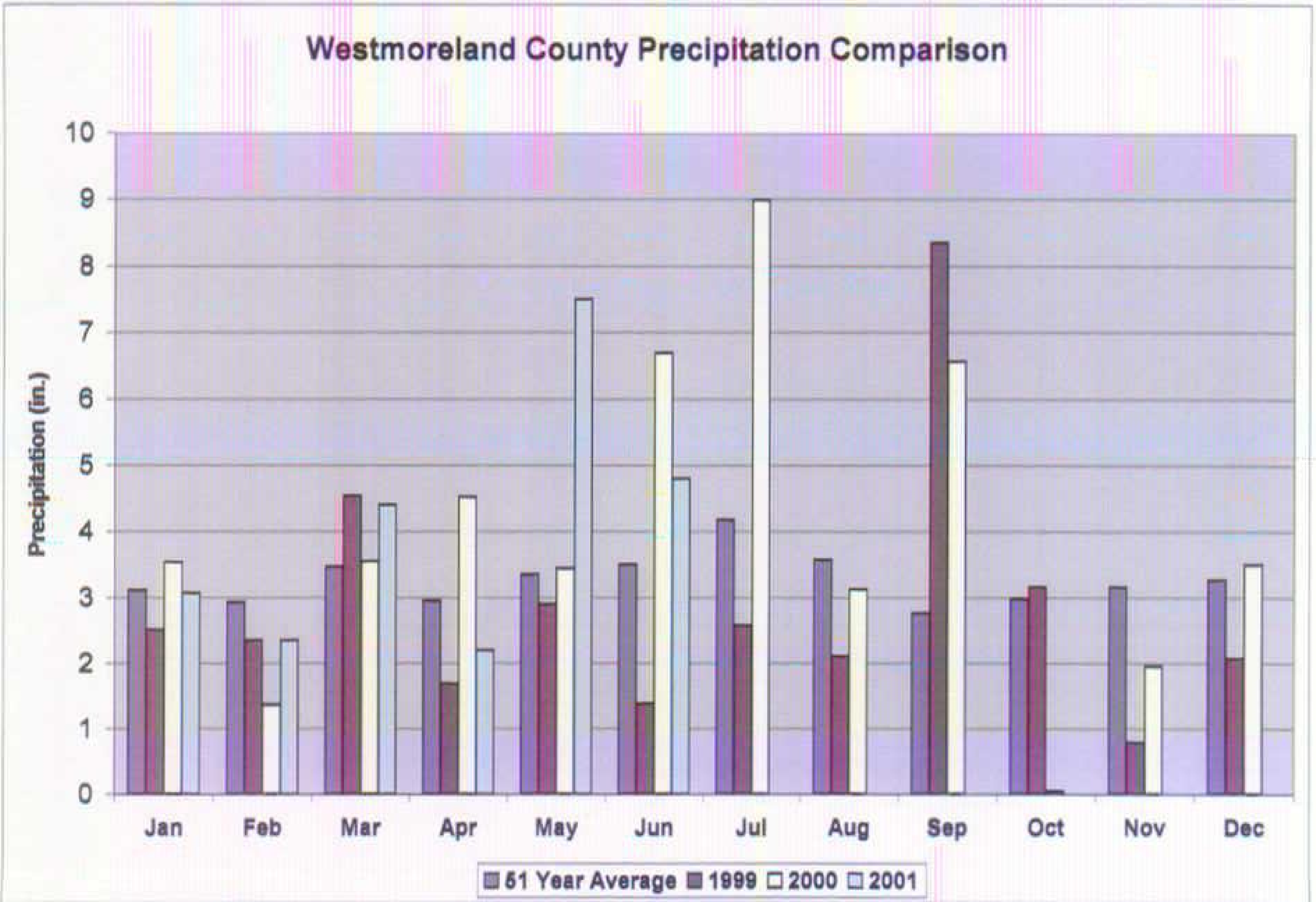
Mobile Home ~
"'---~--- 65'~~_ ~ ~ ..... ~_ .....

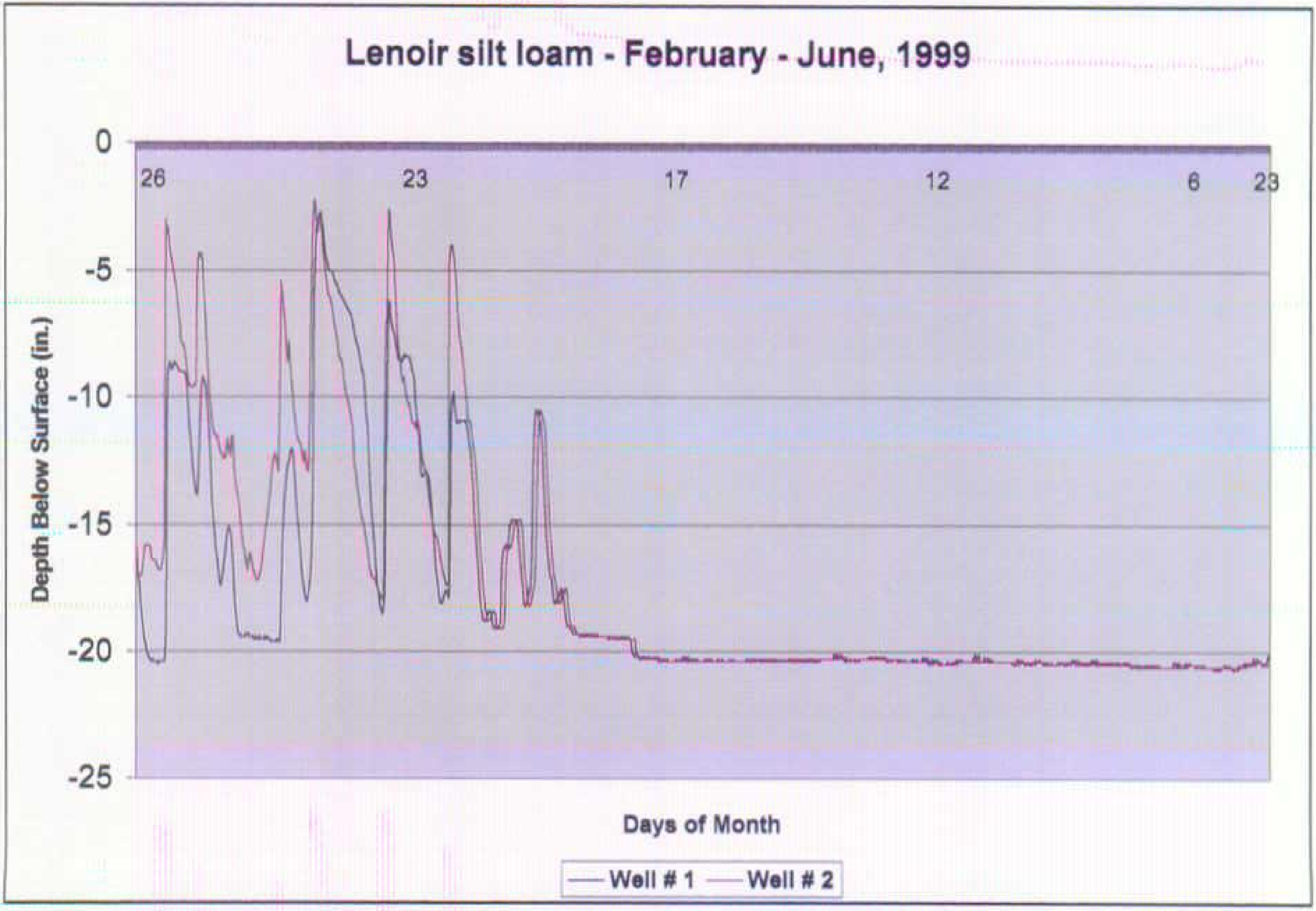
60' ~ Data Logger #1
WL-40
75'

House

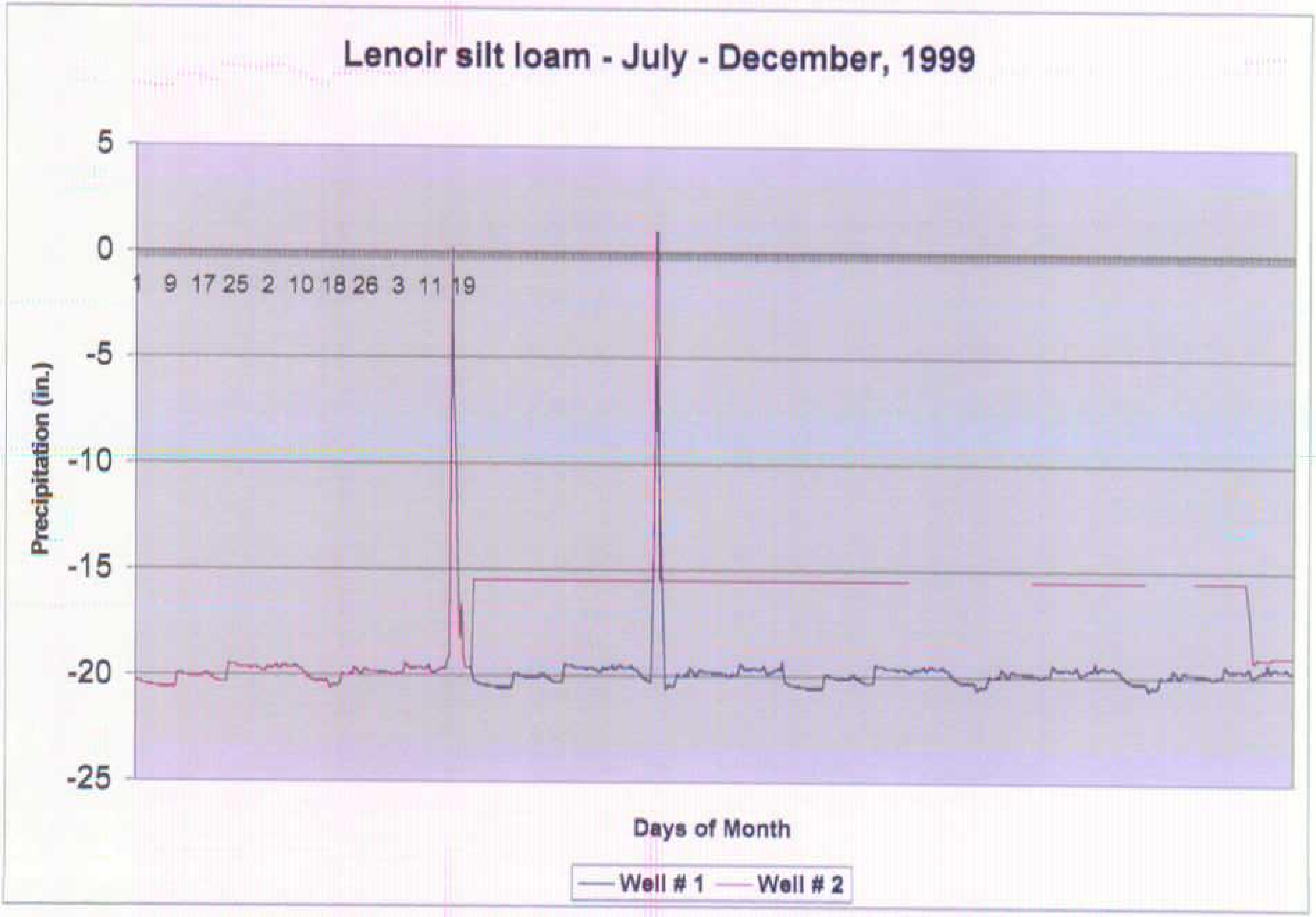


 450 ft Scale: 1 : 12,000 Detail: 14-0 Datum: WGS84

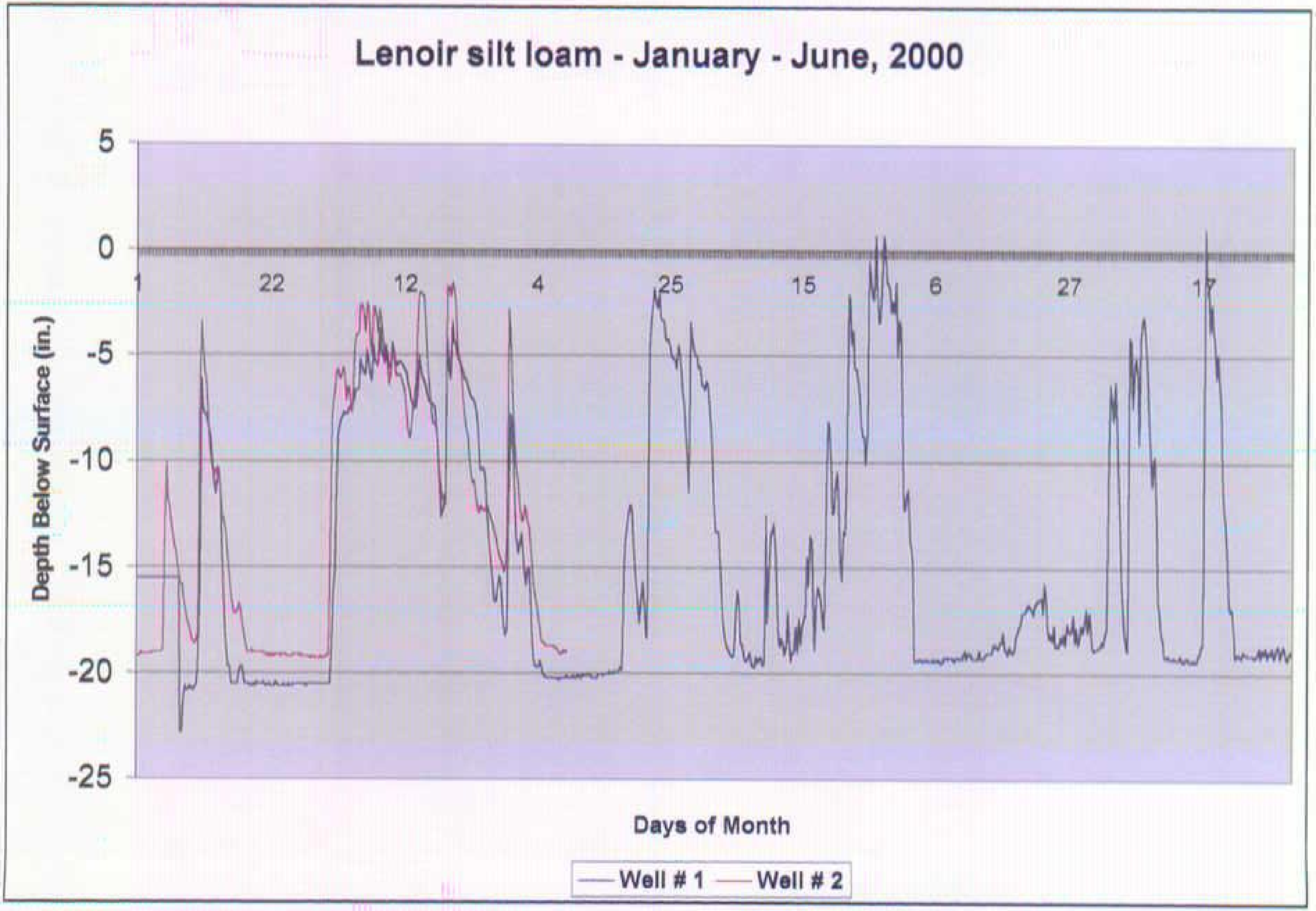

Westmoreland County Precipitation Comparison
Precipitation (in.)
0
1
2
3
4
5
6
7
8
9
10
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
51 Year Average
1999
2000
2001



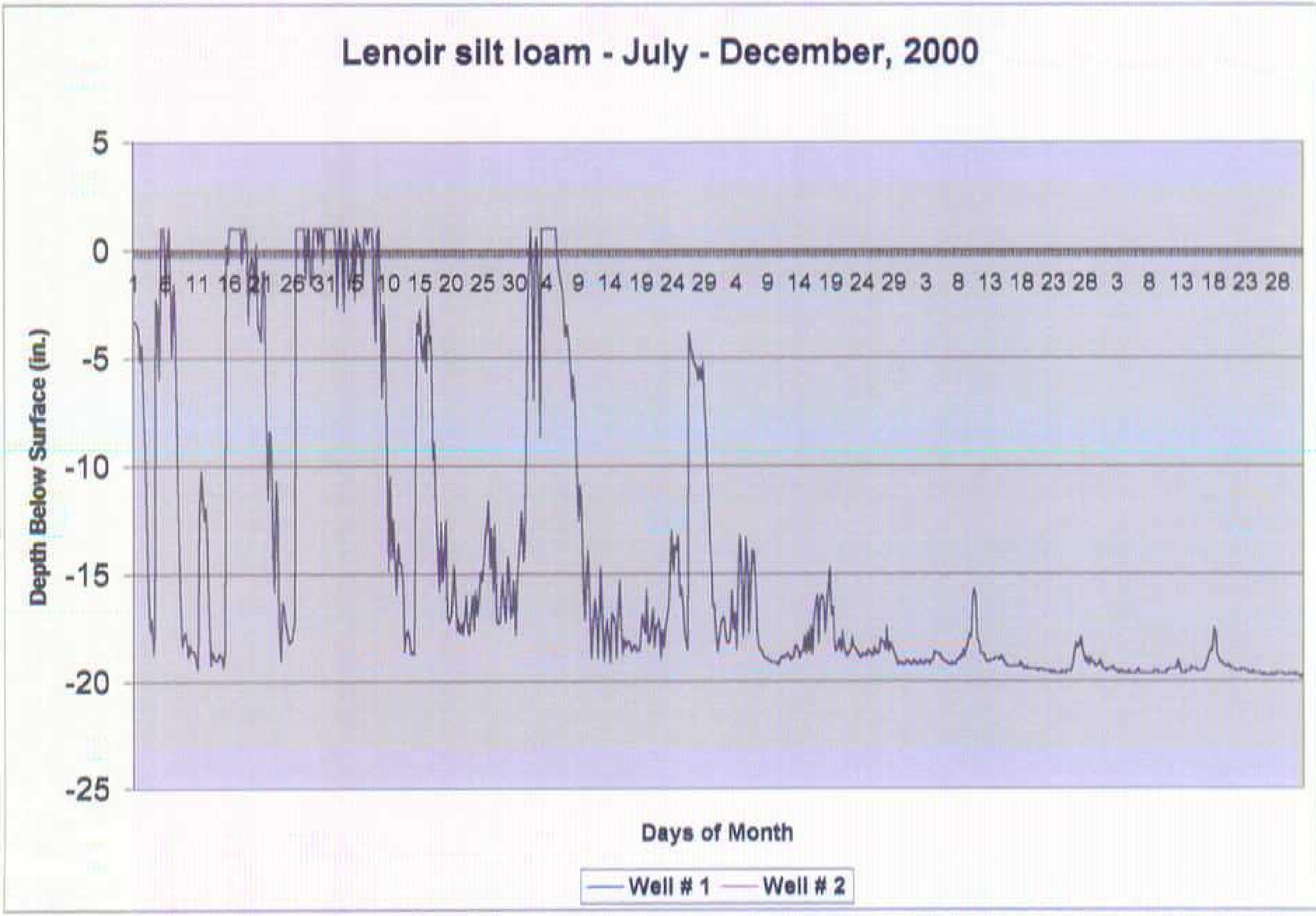
Lenoir silt loam - February - June, 1999
Depth Below Surface (in.)
0
-5
-10
-15
-20
-25
26
23
17
12
6
23
Days of Month
Well # 1
Well # 2



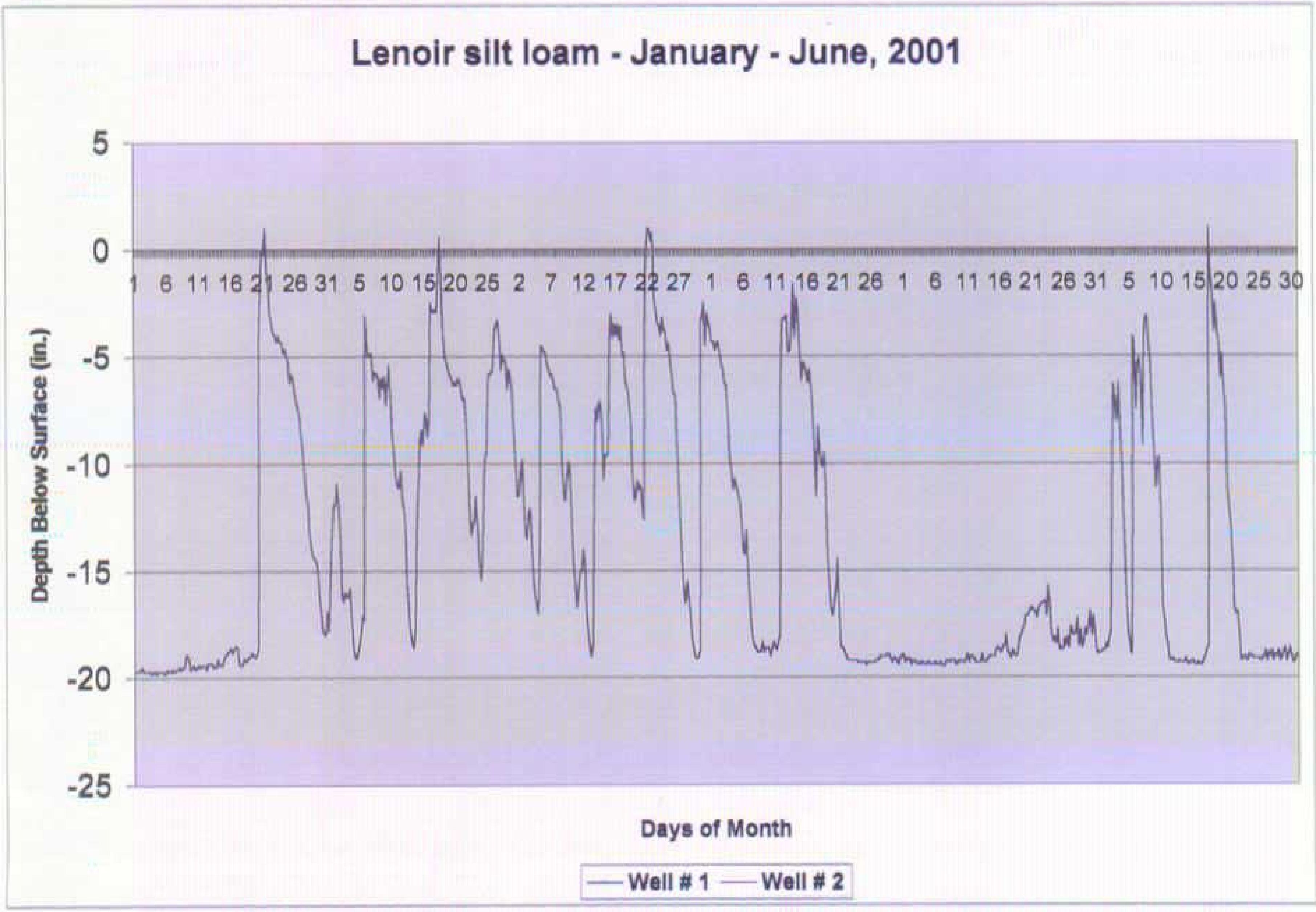
Lenoir silt loam - July - December, 1999
5
0
-5
-10
-15
-20
-25
Precipitation (in.)
1 9 17 25 2 10 18 26 3 11 19
Days of Month
Well # 1
Well # 2



Lenoir silt loam - January - June, 2000
Depth Below Surface (in.)
5
0
-5
-10
-15
-20
-25
1
22
12
4
25
15
6
27
17
Days of Month
Well # 1
Well # 2



Lenoir silt loam - July - December, 2000
Depth Below Surface (in.)
5
0
-5
-10
-15
-20
-25
1 6 11 16 21 26 31 5 10 15 20 25 30 4 9 14 19 24 29 4 9 14 19 24 29 3 8 13 18 23 28 3 8 13 18 23 28
Days of Month
Well # 1
Well # 2



Lenoir silt loam - January - June, 2001
Depth Below Surface (in.)
5
0
-5
-10
-15
-20
-25
1 6 11 16 21 26 31 5 10 15 20 25 2 7 12 17 22 27 1 6 11 16 21 26 1 6 11 16 21 26 31 5 10 15 20 25 30
Days of Month
Well # 1
Well # 2

SOIL EVALUATED: Munden sandy loam

LOCATION:

This research site was located in the central portion of Northampton County, Virginia. Refer to the accompanying portion of the Nassawadox U.S. Geologic Survey topographic map for the general character-of the area. The accompanying detailed site sketch shows the location of two automated WL-40 data loggers on this residential/commercial property. This property provides single family housing for Iow income residents.

RATIONALE FOR SITE SELECTION:

There were several reasons for using this site. First, the type of soil at the site, Munden, represents a major soil type located over large areas in the state. To study it would provide valuable information that could apply to numerous sites considered for onsite septic systems. Second, while the Munden soil meets Virginia criteria to allow installation of a conventional gravity drainfield under the 1982 regulations, it is unsuitable for such a wastewater system under the 2000 regUlations. An alternative type wastewater system would be required for this soil under current regulations. And finally, the residence/commercial dwellings at this site employ an alternative onsite wastewater disposal system, so a water table study would provide information on how well this alternative septic system works-in~problemsoils

SOIL AND SITE INFORMATION:

The soil at this site formed in moderately coarse textured, stratified, unconsolidated, fluvio-marine sediments of the lower Coastal Plain. There was a long, nearly level fiat that lies adjacent to the site. The site was on a gentle ridge. Well # 1 was located in the yard vegetated with fescue-type lawn grasses and Well # 2 was located in the edge of the wooded area vegetated with mixed hardwoods and Ioblolly pine.

The 'published Soil Survey of Northampton County, Vir.qinia, Phillip R. Cobb, et.ah, August 1989, shows the research site as being mapped as Munden sandy loam, 0 to 2 percent slopes (MuA). Munden is a moderately well drained soil.

A detailed soil profile description was made at the site and is included. When compared to the official soil series description for the Munden series (refer to the Appendix), the soil at this site falls within the range of characteristics. That means the soil was typical or representative of Munden soils.

While the soil was suitable for a conventional gravity drainfield using the 1982 regulations, it would not have been suitable for the same type system under the current 2000 regulations. The existing system was a mass drainfield using a subsurface enhanced flow gravity system. Depth to wetness indicators was too shallow to permit this type system.

CLIMATIC DATA FOR THE SITE:

The site was approximately 10 miles from the Eastern Shore Agricultural Research and Extension Center at Painter, where official weather data are collected. Precipitation data from the research center was used to evaluate rainfall during the study period. The precipitation comparison graph shows how each month's rainfall total compares to the monthly 59-year average (1942-2001).

It is apparent that 1999 was an abnormal year. Hurricanes Dennis, Floyd and Irene produced rainfall totals in excess of 14 inches during a six week period from September 3 through October 18. For the January-June period, precipitatiOn was normal with 20.98 inches. For the July-December period, precipitation was above normal. In fact, rainfall was 5.24 inches above normal or 124% of the long-term average for that period. Therefore, the water table levels would be expected to be above normal at the site.

Six of the twelve months (January, March, June, August, September and October, 1999) had precipitation levels above normal. For the entire study period of January-December of 1999, overall precipitation was 5.24 inches above the 59-year~ average~or_l.12% ... Water~.tableJevelsLwould~be~expected-to.~be-normal-at the site.

RESULTS:

Two automated data loggers were installed at the site on February 12,1999. Wells were installed in the same soil, same landscape position and at the same toPographic elevation. Well # I was installed within the footprint of the subsurface mass drainfield and Well # 2 was installed 120 feet away. Well # 2 was representative of the soil conditions at the mass drainfield site but was remote enough to be unaffected by the septic system. Due to operator error, the two automated wells were not programmed properly and the collection of water table data did not commence until March 14,1999. There was continuous data collection from the starting date until April 4,1999 for Well # 1 and December 31, 1999 for Well # 2. Well # 1 was vandalized and did not function after April 4. Well # 2 was removed at the end of 1999 for fear that it might also be vandalized.

The Munden soil at this site had many light gray (10YR 7/1) mottles (or iron depletions) at 30 inches at Well # I and 24 inches at Well # 2 in the Bt2 horizon, making it a moderately well drained soil. These soils normally have an apparent water table, which comes up from the bottom during precipitation events and goes down during dry periods. The mottling at shallower depths in the Bt1 hodzon was suspected to be associated with the fluctuating seasonal water table.

The water table hydrograph of March - June, 1999 shows the presence of free water in the soil within 12 inches for 0-2 days, 12-18 inches for 0-8 days, 18-24 inches for 0-20 days, 24-30 inches for 3-32 days, 30-36 inches for 10-39 days, 36-40 inches for 16-43 days and dry for 6-66 days. Rainfall for this period was average or 20.98 inches. March and June were above normal in precipitation but April and May were below normal.

The March - June, 1999 Groundwater Data Table shows that the surface of the free water for Well # 1 was never in the Ap, E nor upper Bt1 horizons during this 22 day period but was in the lower Bt1 horizon 3 days or 13% of the time, in the Bt2 horizon 10 days or 47% of the time and the Btg 16 days or 73% of the time. The Cg horizon was dry for 6 days or 27% of the time. For Well # 2, the surface of the free water was in the Ap horizon 2 days or 2% of the time during this 109 day period, in the E horizon 8 days or 8% of the time, in the Bt1 horizon 20 days · or 18% of the time, in the Bt2 horizon 32-39 days or 30-36% of the time and the Btg horizon 43 days or 39% of the time. The Cg horizon was dry for 66 days or 60% of the time.

The water table hydrograph of July - December, 1999 shows the presence of free water in the soil within 12 inches for 5 days, 12-18 inches for 8 days, 18-24 i nches-for--~l-1-- days,.. 24~30-inches~_fo r-.-19-days,. 30=36Jnches_for_38_days,_36--4.0 ...... inches for 60 days and dry for 124 days. Rainfall for this period was above average or 27.06 inches. Precipitation during this six week period of the hurricanes was 15.26 inches but only 5.24 inches above normal for the entire six month period. Most of the remainder of the time was well below normal rainfall.

The July - December, 1999 Groundwater Data Table shows that the surface of the free water for Well # 2 was in the Ap horizon 5 days or 3% of the time during this 184 day period, in the E horizon 8 days or 5% of the time, in the Bt1 horizon 11 days or 6% of the time, in the Bt2 horizon 19-38 days or 11-21% of the time and the Btg horizon 60 days or 33% of the time. The Cg horizon was dry for 124 days or 67% of the time.

CONCLUSIONS:

This site had precipitation levels above normal for 5 months of the 10 months the study was conducted. Those five months, March, June, August, September and October had totals of 31.89 inches, 6.09 inches above normal. That relates to 172% of normal precipitation for those 5 months. The total study period (10 months) had 41.91 inches. Based on the 59-year average, this relates to 117% of normal precipitation.

In spite of near normal precipitation, free water was present for significant pedods of time during the study period at lower depths in the soil. In addition, the depth to free water was much shallower than where gray mottles were found in the soil. Once the water table rose in the soil, it remained for an extended period of time. Well # I only functioned for 22 days during this study due to vandalism. The first number of days listed in the results relates to Well # I and will be Iow due to few days the data logger functioned. Therefore, some of the results will appear to be Iow.

Free water was observed in the Ap and E horizons for short pedods of time and was always associated with precipitous rises in the water table. For the entire study period, free water was in these hodzons for 0 to 16 days of the total 293 days or 0 to 5 percent of the time, though not continuously. There were no soil morphological features that could be related to the presence of water in the soil for the number of days observed.

Free water was observed in the Bt1 horizon for 3 to 31 days of the total 293 days during the entire study period and was always associated-with sharp rises in the water table. This relates to I to 11 percent of the time. Pale brown (10YR 6/3) mottles were soil morphological features that could be related to the presence of water in the soil for the number of days observed.

Free water was obServed in the Bt2 hodzon for 10 to 39 days of the total 293 days~d u ri ng-the~enti re-study-,period~and~was, always-associated~*with sh a rp,.-rises .... in the water table. This relates to 3 to 13 percent of the time. Pale brown (10YR 6/3), strong brown (7.5YR 5/6) and light gray (10YR 7/1) mottles were soil morphological features that could be related to the presence of water in the soil for the number of days observed.

Free water was observed in the Btg horizon for 16 to 60 days of the total 293 days during the entire study period and was always associated with sharp rises in the water table. This relates to 5 to 20 percent of the time. Pale brown (10YR 6/3) and brownish yellow (10YR 6/6) mottles in a gleyed matrix were soil morphological features that could be related to the presence of water in the soil for extended pedods of time.

Free water was observed in the Cg horizon for 124 days of the total 293 days during the entire study period. This relates to 42 percent of the time. Pale brown (10YR 6/3) and brownish yellow (10YR 6/6) mottles in a gleyed matrix were soil morphological features that could be related to the presence of water in the soil for extended periods of time.

The presence of strong brown (7.5YR 5/6) and pale .brown (10YR 6/3) redoximorphic features (mottles) were soil morphologic features that could be related to the presence of water in the soil for some periods of time. During the winter-spring time of the year, the seasonal water table was present in the Bt1 horizon for; less than 1/6 of the time.

It must be remembered that when the surface of the water table was in one of the upper horizons such as the Bt1, the Bt2 and lower horizons were saturated for longer periods. Free water was observed in the Bt2 horizon for 1/3 to 2/5 of the time. These horizons had pale brown (10YR 6/3), strong brown (7.5YR 5/6) and light gray (10YR 7/1) redoximorphic features (mottles).

Redoximorphic features (mottles) in the Btg horizon were exhibited as brownish yellow (10YR 6/6) and pale brown (10YR 6/3) mottles in a gleyed matrix. Free water was observed in the Btg horizon for 1/6 to 2/5 of the time. Since this horizon was lower in the profile and gleyed, the seasonal water table would be expected to have a longer duration than the upper horizons.

Redoximorphic features (mottles) in the Cg horizon were exhibited as brownish yellow (10YR 6/6) and pale brown (10YR 6/3) mottles in a gleyed matrix. Free water was observed in the Cg horizon for more than 1/2 of the time. Since this was the lowest horizon in the profile and gleyed, the seasonal water table woUld be expected to have a longer duration than the upper horizons.

As was noted earlier, this soil exceeded the minimum state requirements for a conventional gravity drainfield based on soil morphology. Based on the period studied, it is apparent that the gravel filled trenches (at a depth of 18 inches) for the existing conventional septic system would have been inundated with free water for very short periods of time. Based on the state sewage regulations in effect when the permit was issued, a 6-10 inch zone of suitable soil beneath the gravel filled trenches would have been required (the "stand-off zone") for treatment and disposal of the wastewater. Based on this research, the seasonal water table would have been in the "stand-off zone" at least 20 to 32 days or 18% to 30% of the time during a winter-spring period. Although soil morphology indicated this soil was suitable for a conventional gravity drainfield, the monitoring data taken while there was slightly above normal precipitation showed the soil was marginal.

An elevated Wisconsin mound system was installed at this site and it required a "stand-off zone" of 18 inches beneath the surface. Based on this installation depth, the seasonal water table would have periodically risen into the "stand-off zone". Based on this research, the seasonal water table would have been in the "stand-off zone" at least 49% to 56% of the time during a winter-spring period.

Munden sandy loam

Profile for Well # 1: (WL40)

Ap--0 to 12 inches, dark grayish brown (10YR 4/2) and black (10YR 2/1) sandy loam; weak coarse granular structure; friable, nonsticky, nonplastic.

E--12 to 18 inches, light yellowish brown (10YR 6/4) sandy loam; massive; friable, nonsticky, nonplastic.

Btl--18 to 30 inches, yellowish brown (10YR 5/6) loam; common medium distinct pale brown (10YR 6/3) mottles; weak medium subangular blocky structure; friable, slightly sticky, slightly plastic.

Bt2--30 to 36 inches, yellowish brown (10YR 5/6) loam; many medium distinct pale brown (10YR 6~3), strong brown (7.5YR 5/6) and light gray (10YR 7/1) mottles; weak medium subangular blocky structure; friable, slightly sticky, slightly plastic.

Btg--36 to 42 inches, light brownish gray (10YR 6/2) sandy loam; many medium and coarse distinct brownish yellow (10YR 6/6) and pale brown (10YR 6/3) mottles; weak coarse subangular blocky structure; friable, slightly sticky, nonplastic.

Cg--42 to 48 inches, light brownish gray (10YR 6/2) loamy sand; many medium and coarse distinct brownish yellow (10YR 6/6) and pale brown (10YR 6/3) mottles; single grained; loose, nonsticky, nonplastic

Remarks: This profile taken from an auger hole. Irregular color and thickness of the Ap horizon is due to historic fill of the site.

Profile for Well # 2: (WL40)

Ap--0 to 12 inches, dark grayish brown (10YR 4/2) and black (10YR 2/1) sandy loam; weak coarse granular structure; friable, nonsticky, nonplastic.

E--12 to 18 inches, light yellowish brown (10YR 6/4) sandy loam; massive; friable, nonsticky, nonplastic.

Btl--18 to 24 inches, yellowish brown (10YR 5~6) loam; common medium distinct pale brown (10YR 6/3) mottles; weak medium subar~gular blocky structure; friable, slightly sticky, slightly plastic.

Bt2--24 to 36 inches, yellowish brown (10YR 5/6) 10am; many medium distinct pale brown (10YR 6/3), strong brown 7.5YR 5/6) and light gray (10YR 7/1) mottles; weak medium subangular blocky structure; friable, slightly sticky, slightly plastic.

Btg--36 to 42 inches, light brownish gray (10YR 6/2) sandy loam; many medium and coarse distinct brownish yellow (10YR 6/6) and pale brown (10YR 6/3) mottles; weak coarse subangular blocky Structure; fdable, slightly sticky, nonplastic.

Cg--42 to 48 inches, light brownish gray (10YR 6/2) loamy sand; many medium and coarse distinct brownish yellow (10YR 6/6) and pale brown (10YR 6/3) mottles; single grained; loose, nonsticky, nonplastic

Remarks: This profile taken from an auger hole. Irregular color and thickness of the Ap horizon is due to historic fill of the site.

Table I - - Munden sandy loam Groundwater Data Table
March-June, 1999 (109 Days)

	Well # 1				Well # 2			
Depth Range (in.)	Number of Days	Percent Time	Percent Cumulative Days	Cumulative Days	Number of Days	Percent Time	Percent Cumulative Days	Cumulative Days
0-6	0	0	0	0	0	0	0	0
6.1-12	0	0	0	0	2	2	2	2
12.1-18	0	0	0	0	6	5	8	8
18.1-24	0	0	0	0	12	11	20	18
24.1-30	· 3	13	3	13	12	11	32	30
30.1-36	7	33	10	47	7	7	39	36
36.1-40	6	27	16	73	4	4	43	39
Dry	6	27	22	100	66	60	109	100

Table 2 - - Munden sandy loam Groundwater Data Table
July-December, 1999 (184Days)

	Well # 1				Well # 2			
Depth Range (in.)	Number of Days	Percent Ti~e'	Percent Cumulative DRys'	Cumulative DRys	Number of'DRys	Tiifie	Percent Cumulative Diays	Cumulative Days
0-6					2	1	2	1
6.1-12					3	2	5	3
12.1-18					3	2	8	5
18.1-24					3	2	11	6
24.1-30					8	4	19	11
30.1-36					19	10	38	21
36.1-40					22	12	60	' 33
Dry					124	67	184	100

Number of Days column refers to the number of days the surface of the free water was present within the depth range.
Percentage of Time column refers to the percent of time the water was present within the depth range.
Cumulative Days column refers to the total number of days the water was present within the depth range.
Percentage of Cumulative Days refers to the percent of total time the water was present within the depth range.
DRY corresponds to the number of readings (converted to days) where the monitoring well

recorded no water in the hole.

Days in the column headings corresponds to the number of data logger readings within a depth range divided by the number (normally 2, 4 or 8) of data logger readings per day.

Northampton County
Munden Sandy Loam
Scale: 1"= 30'

, ~.~.~ Data Logger #2

. WL-40

Saw Mill

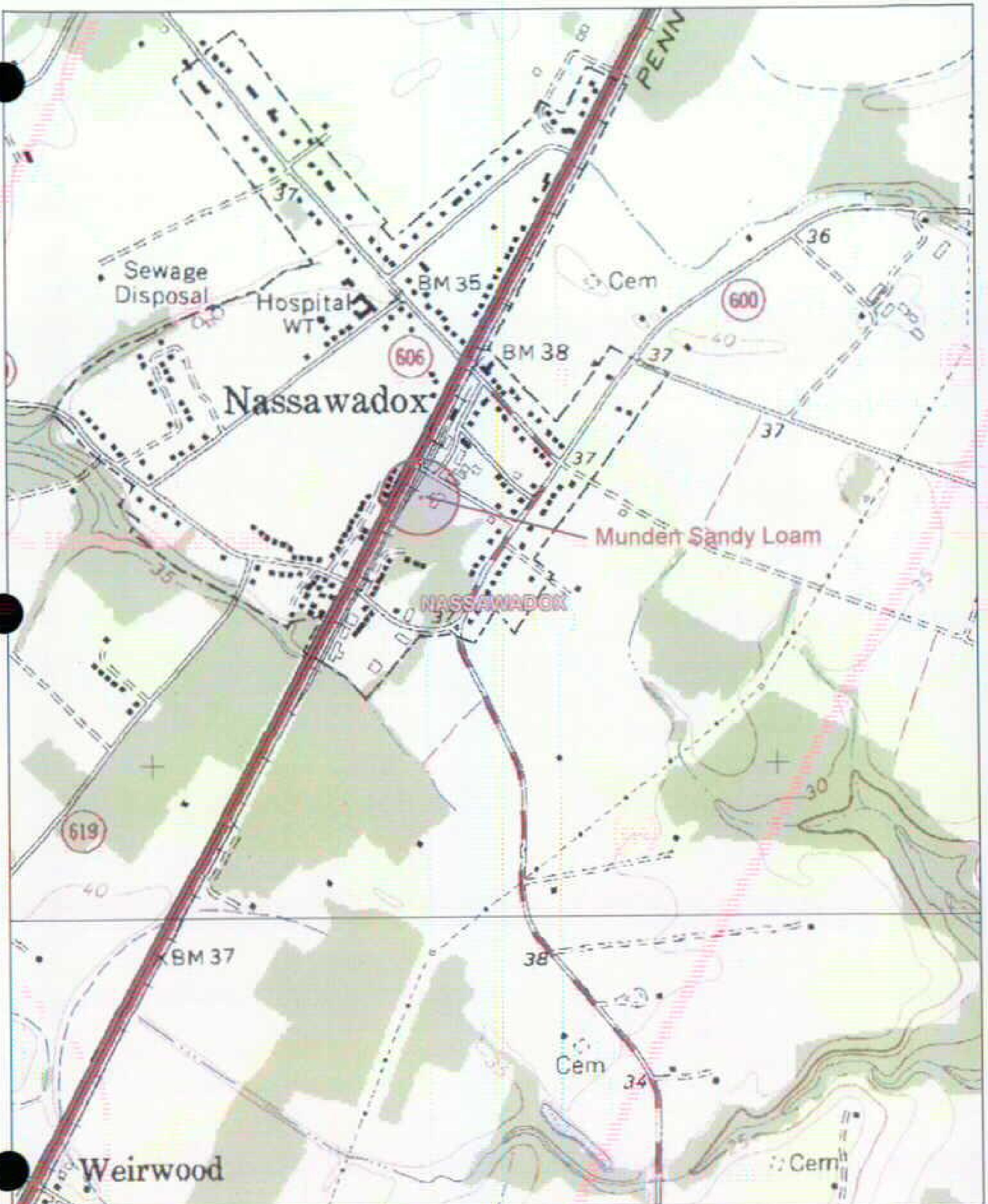
20'

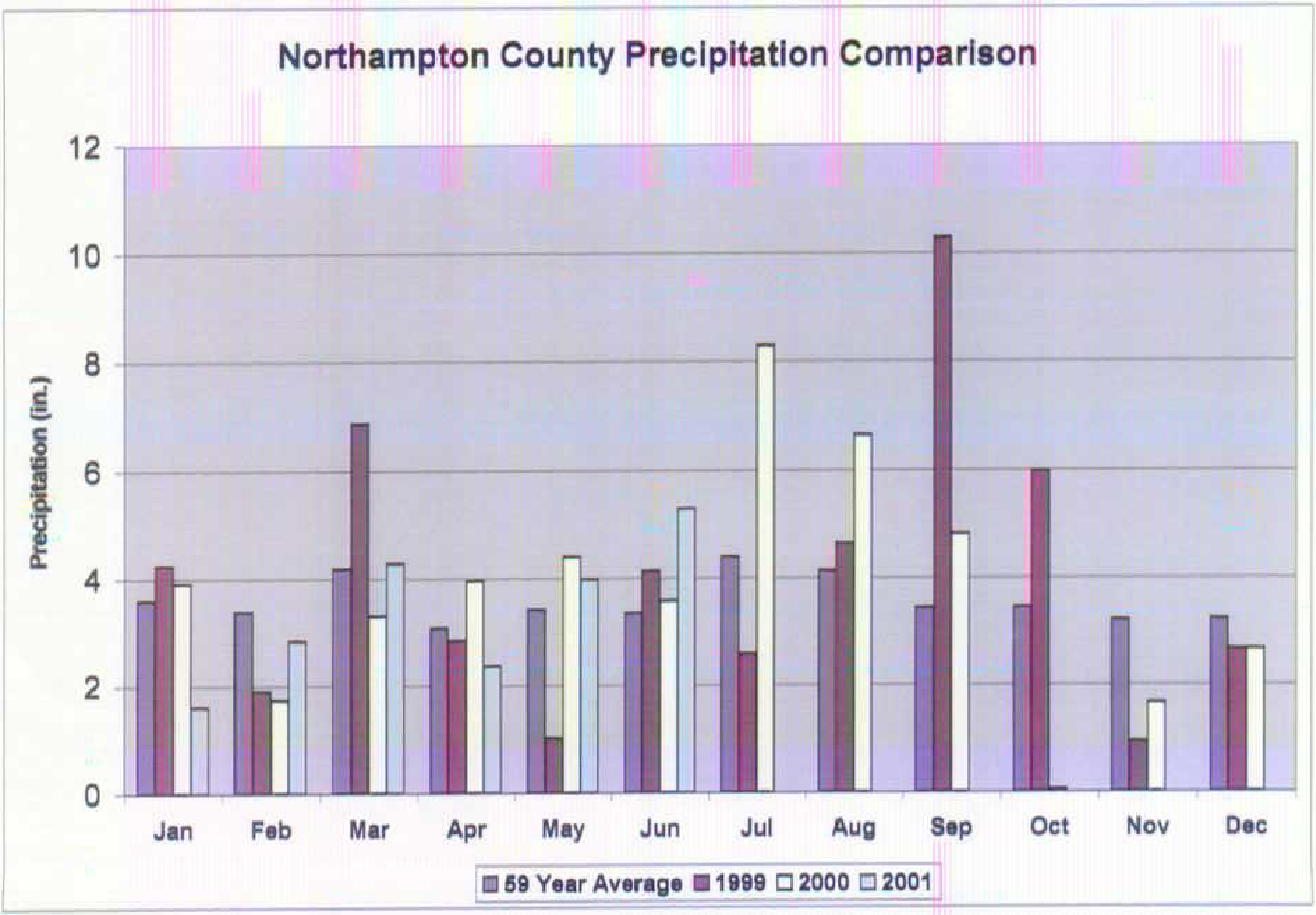
~ Data Log~fr ~1

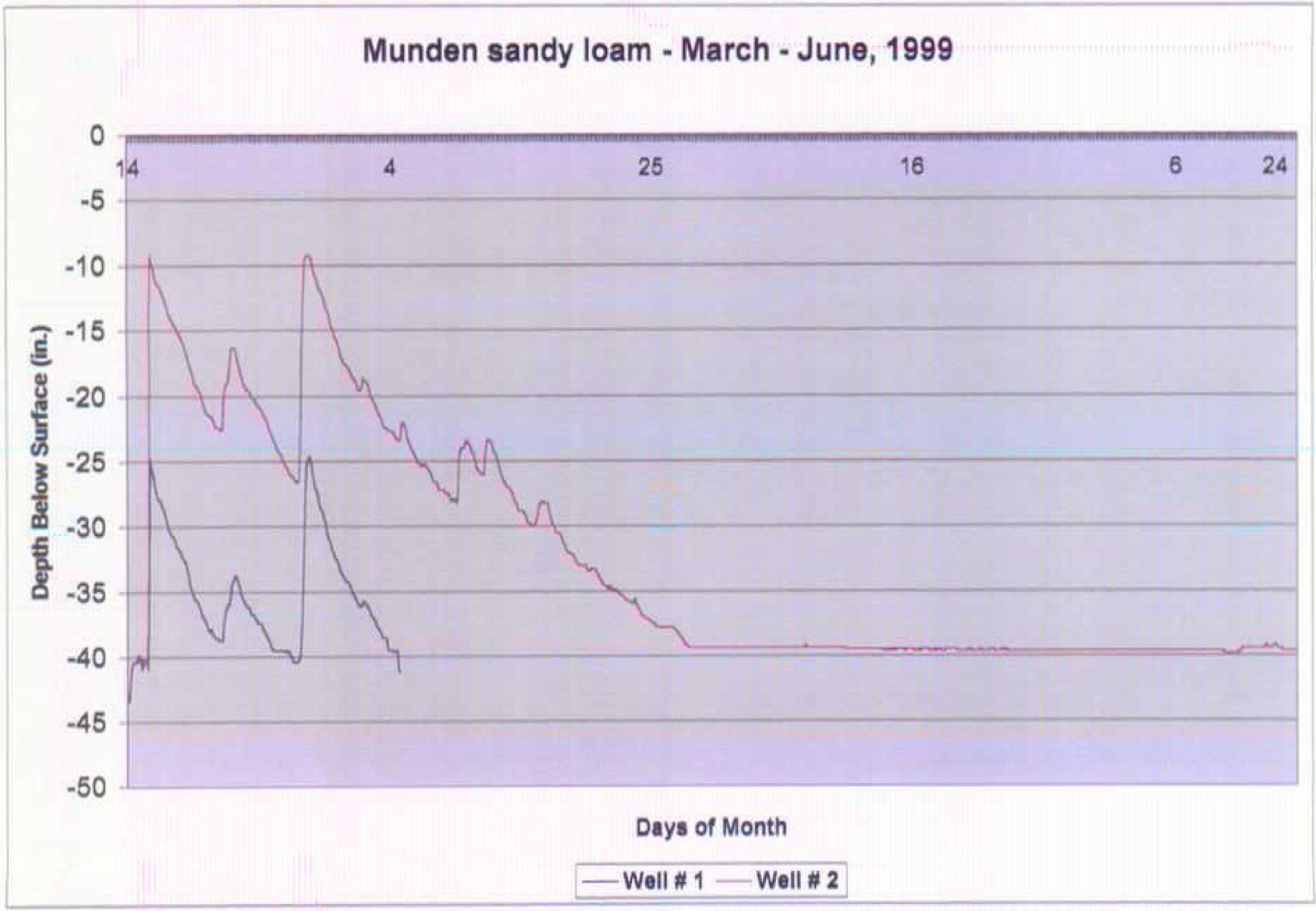
', /WL-40

2~'

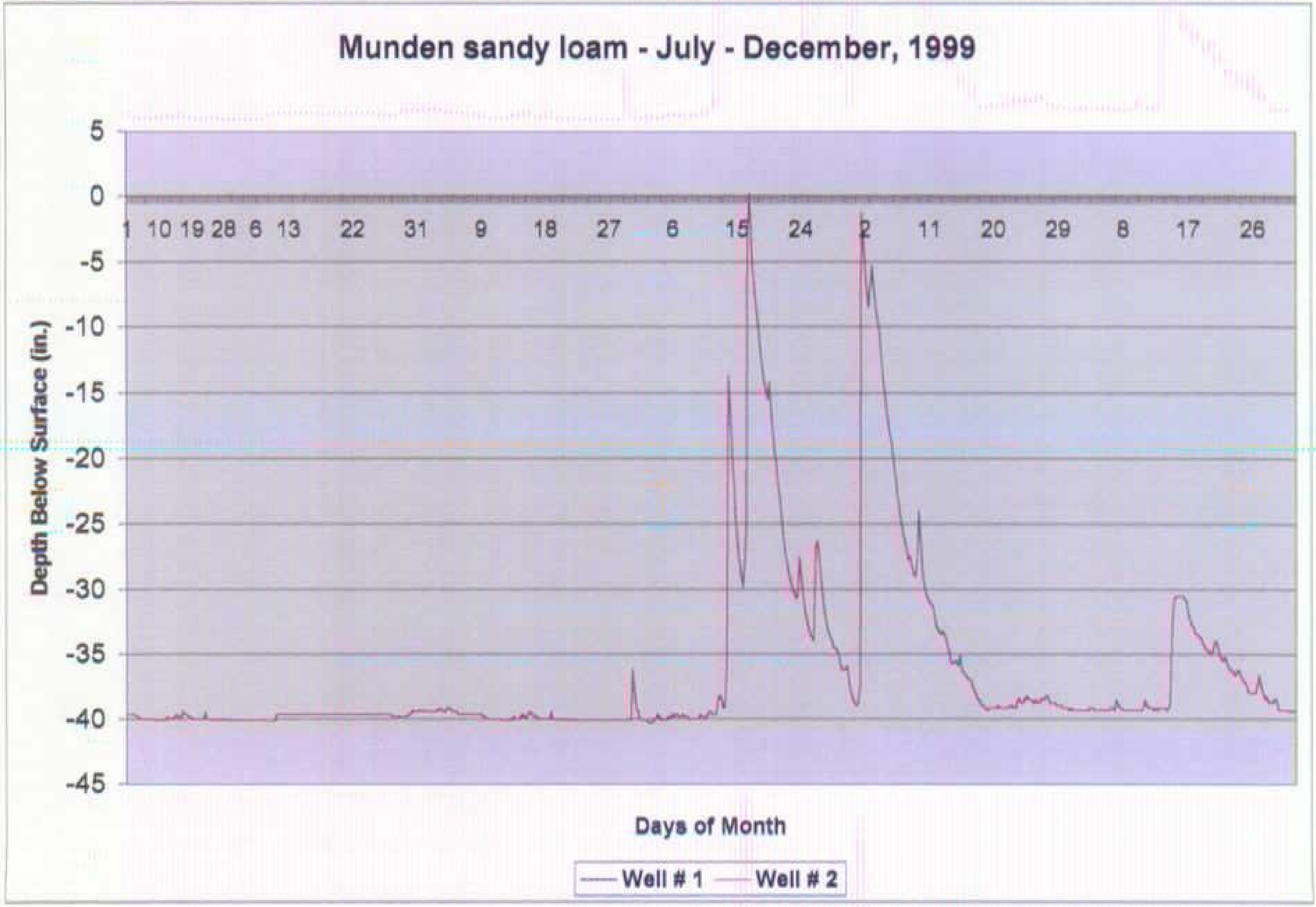
Conventional Subsurface System


PENN
Sewage
Disposal
Hospital
WT
BM 35
Cem
600
36
606
BM 38
37
40
Nassawadox
37
37
Munden Sandy Loam
NASSAWADOX
35
37
619
30
40
BM 37
38
Cem
34
Cem
Weirwood


Northampton County Precipitation Comparison
Precipitation (in.)
12
10
8
6
4
2
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
59 Year Average
1999
2000
2001



Munden sandy loam - March - June, 1999
Depth Below Surface (in.)
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
14
4
25
16
6
24
Days of Month
Well # 1
Well # 2


Munden sandy loam - July - December, 1999
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
Depth Below Surface (in.)
1 10 19 28 6 13 22 31 9 18 27 6 15 24 2 11 20 29 8 17 26
Days of Month
Well # 1
Well # 2

SOIL EVALUATED: McGary silt loam

LOCATION:

This research site was located in the central portion of Montgomery County, Virginia. Refer to the accompanying pOrtion of the U.S. Geologic Survey Radford North topographic map for the general character of the area. The topographic map portion also indicates the general location of a WL-40 automated data logger on the property.

RATIONALE FOR SITE SELECTION: ·

There were several reasons for selecting this site. First, I have earlier data from a previous water table study that would be verified with additional data. Second, there were shallow horizons present that were thought to be restrictive to downward water movement that would show up with a longer study period. Hence as part of the second idea, I was trying to determine if the water table was perched or did it rise from the lower depths or were both suggestions correct. The site was too wet for any system except spray irrigation. However, with a stream and spring nearby no system could be considered without moving the system away from the stream and spring to meet standoff distances:

SOIL AND SITE INFORMATION:

The soil at this site formed in moderately fine textured alluvial sediments of the New River. There was a broad Iow terrace and the well was installed in the backswamp landscape position at the rear of the terrace. The site was near a small stream in the backswamp position. The WL-40 data logger well was installed in a fescue grass buffer zone between the small stream and the cornfield. McGary silt loam is a poorly drained soil.

The site was evaluated as a study site for a future training session. The participants of the study classified it as Zoar silt loam. A very detailed soil profile description was made at the site and is included. Dr. William Edmonds and Dr. Pamela Thomas of the Crop and Soil Environmental Sciences Department wrote. the soil description. When compared to the official soil Series description for the McGary series (refer to the Appendix), the soil at this site falls within the range of characteristics. That means the soil was typical or representative of McGary soils.

The site is not suitable for any onsite system permitted by the Virginia Department of Health due to the stream location and soil characteristics.

CLIMATIC DATA FOR THE SITE:

The site was less than 1 mile from the Kentland Weather Station where official NOAA weather data are collected, so precipitation data from the station was used to evaluate rainfall during the study pedod. The precipitation comparison graph shows how rainfall totals each month compares to the monthly 25-year average (1965-1990) for Montgomery County.

It is apparent that for the January-December 1999 pedod, precipitation was well below normal with only three months having near or exceeding the 25-year average. Storms of July and September delivered almost 5-inches more rain than normal. The last three months of 1999 were very dry and water tables would be expected to be falling or dropping in the soil profile.

For the period January-June 2000, total precipitation was nearly 2.0 inches below the 25-year average. With 1999 being dry and the first six months of 2000 also experiencing lower than normal rainfall, the water table levels would be expected to be lower than under_ normal conditions at the site.

For the period July-December 2000, monthly rainfall .was well below normal by 5.0 inches. It is noteworthy that only 0.01 inches of rain was recorded for the entire month of October 2000, making it the driest OctOber since data collection began in southwest Virginia. The October-December 2000 period was extremely dry. In fact, rainfall was only 49% of the long-term average for that 3 month span. That dry fall situation was very similar to moisture conditions noted for October-December 1999. Therefore, the water table levels at the site would be expected to be deeper in the soil profile than during a fall with normal precipitation.

For the period January-June 2001, monthly rainfall was generally below normal. January-May 2001 rainfall was 4.26 inches below the 25-year average, or 25% below normal. Therefore, the water table levels at the site would be expected to be shallower during a winter and spring with normal precipitation.

Except for a few exceptional wet months the overall precipitation situation was one of below normal to near drought conditions. It should be noted that the original project completion date was extended due to severe drought conditions in most of the state during 1999. The year of 2000 was also well below normal precipitation.

RESULTS:

An automated WL-40 data logger well was installed on February 4, 2000. The well location was placed to be representative of the soil conditions at the site. Data was collected continuously from the starting date until April 3, 2001.

The McGary soil at this site had a very dark grayish brown (10YR 3~2) matrix col(~r and was considered to have a gleyed horizon at depths of 11 to 19 inches, making it a poorly drained soil. Iron and manganese nodules were identified in the horizon. Normally, it would be assumed that the seasonal water table would be below 11 inches, while there might be brief periods where it was above that depth. These soils normally have both perched and rising water tables.

The horizons beneath the Acg are considered to be restrictive. All of the lower horizons have iron and manganese nodules and gray mottles indicating wetness. The mottling at deeper depths in the Bt1, Bt2 and C-horizons was suspected to be associated with the fluctuating seasonal water table. The horizons did not become gleyed because all of the factors (time, organic matter, temperature, microbes, saturation and iron) necessary were not present at the correct weathering time.

The water table hydrograph of January-June 2000 shows the presence of free water in the soil at a depth of 11-19 inches on two occasions and lasting a total of twelve days, hardly enough time to produce gray mottles. During my first study years earlier, water was present within the 11-19 inch range for most of the winter. The absence now of any appreciable amount of free water is a direct result of the drought. Water table levels were already Iow due to the drought of 1999. When rain events did start to occur in April-May in appreciable amounts, plants were beginning to leaf out. The rapid spring growth of plants normally starts the lowering of the water table. January and March rainfall totals were about 65% of normal. When coupled with the dry fall of 1999 water tables were still being depressed by Iow additional rainfall. The water table rose above 35 inches, but not 30 inches, three times during the six-month period. A more typical pattern would have been a water table presence in the 11 to 19 inch horizon for almost the entire months of January, February and March.

The July-December 2000 hydrograph shows the water table spiked between the depths of 11 to 19 inches once in early August. As mentioned earlier,' a rapid drop in the free water level starting in early April-May corresponding to shrubs and trees leafing-out and a rapid increase in the evapotranspiration rate at the site. The effect of this leaf-out continues throughout the summer months. The data logger remained dry for part of May and all of June, except for a few spikes of rapid water table rise and fall. July and August had near normal rainfall totals during 2000. After mid-August, the water table level was at or greater than 40 inches below the. soil surface. All of the remaining months of 2000 recorded below normal levels of rainfall, with October recording 0.1 of an inch. Rainfall levels were 72% of normal for the year. In essence, water table levels were not recharged and remained depressed due to the drought.

The seasonal water table was deeper than the depth to gray mottles for 142 days or at least 77% of the time for this monitoring period. The reality was that for the July-December period, the seasonal water table was nearly always thirty inches below the depth to gray mottles in the soil.

A rise in the water table would be expected in a December with normal rainfall. The soil was so dry that any rainfall merely moistened the upper soil horizons. No additional moisture was available to recharge the water table.

The January-April 2001 hydrograph shows many dry hole readings in early January and mid-February. There was a moderate rise in the free water level in mid to late January, rising to 20 inches below the surface. The water table gradually descends to a dry level of recording near 40 inches. In early March, a small rise to 34 inches occurred and remained at that level approximately one week. A stronger, sharper spike occurred in late March. Reading points of one day at four-hour intervals were 40.9, 26.7, 17.1 and 12.7 inches. Poorly drained soils exhibit a fast sharp reaction with adequate moisture recharge. The hydrograph provides a visual clue as to the speed and height of the rise.

The rises shown on the hydrograph exhibit quick responses of the water table to rainfall even during a drought. With normal wet winter months, the water table should remain neat the ten-inch level. The January-April, 2001 Groundwater Data Table indicates the water level was within the 11 to 19 inch depth range for 9 days or 10 % of the time during the period. ^ gleyed horizon should have water present for weeks at a time, not two small spikes.

Lower than normal rainfall for the last couple of years continues to depress the water table levels in southwest Virginia. How long after normal rainfall begins will it take for the water tables to return to normal levels is the question?

Free water was present in the 19 to 40-inch depth range or Bt1 horizon. The data table for January-April, 2001, indicates a time range of 18 to 40 days for water being present in the Bt1. Free water was present for eighteen days in the 19 to 24 inch level. Water table readings for forty days would be for water in the 40-inch level or lower part of the Bt1 horizon. For 42% of the time, the lower part of the Bt1 was saturated. The numerous gray mottles (four values) are the strongest visible wetness clue for the horizon. With normal rainfall, longer periods of saturation time in the Bt1 would be recorded.

The seasonal water table was deeper than the depth to gray mottles for most of the time period. The reality was that from January 2000 thru early April 2001, the seasonal water table was within the depth range of the Acg hodzon for a total of 27 days. With normal precipitation levels, the water table should have been present for 120 to 150 days or the months of January, February and March of each year.

CONCLUSIONS:

This site had precipitation levels well below normal for the majority of the study period. Rises in the water table were infrequent and of short duration. The water table was not present in any horizon for a significant period during the study due to the drought. As of November 2000, the precipitation levels in western Virginia are 13 inches below normal. This is the fourth year in a row with below normal precipitation.

There were no soil morphologic features that could be related to the presence of water in the soil for the number of days observed. Under normal precipitation, it would be expected that the seasonal water table would be in the ^cg and Bt1 horizons for significantly longer periods of time than actually occurred.

The presence of common yellowish red redoximorphic features (mottles) in the Bt1 and Bt2 reflects the presence of the seasonal water table for some period of time. It can only be expected that under normal precipitation, the seasonal water table would be in the yellowish red mottled Bt1 and Bt2 horizons for longer periods of time. Also, the gray mottles with four different values, suggest the presence of the water table for extended periods of time.

The location of this site in the backswamp position along the lower edge of a Iow terrace, with a long gentle slope of 1%, may have contributed to the-development of a water table. With a 1% slope, very little runoff will occur and surface ponding would be expected during wet periods. The small stream channel allows water to move away from the area. The channel intercepts water moving from the upland positions and directs the water away from the well location. In other words, without the stream channel the site would be even wetter.

As was noted earlier, this soil does not meet the minimum state requirements for any onsite system as permitted by the Virginia Department of Health based on soil morphology and landscape position. Based on the two winter-spring monitoring periods studied, it is apparent that if a conventional septic system had been installed, the gravel filled trenches (at a depth of 18 inches) would have rarely had free water present even for bdef periods of time.

The study at this location illustrates the need of the use of soil morphology clues during site investigations for onsite septic systems. Using only data logger information, the site would be suitable for most any type of system. In reality, in any year with normal rainfall, an onsite system would fail between December and May if installed at this location.

The study also illustrates the need for the backswamp landscape position to be eliminated from possible sites for onsite systems. Backswamp positions are similar to drainage way positions in the sense they collect and channel water but are much wetter and often have water ponded. The position should not be considered for a house site even if a septic system is located some distance away because of the high moisture levels normally present. The high moisture levels will mean higher moisture levels in the floors and walls of the house, which create mold, mildew and respiratory problems for the occupants.

The continuous readings at or below the 40-inch level raised questions as to what was the real water table depth. The three hydrographs exhibit many very small spikes along the 40-inch depth line that seemed to occur almost each day. ^ deeper or longer well such as the WL-80 should be incorporated into a study if the 40-inch depth range information is critical to a project.

A manual well should be installed in any project involving data loggers. Manual wells as backups would cover battery failures, improper programming, poor downloading and false readings. An auger hole should be bored each month to visually inspect the soil in order to relate the readings to actual soil conditions.

McGary loam

Profile for Well # 1 (WL40)

Ap--0 to 11 inches; dark brown (10YR 3/3), broken, loam; moderate medium and coarse granular structure, friable, sticky, plastic; few very fine roots; many medium tubular pores; 2 percent rounded and subrounded chert, feldspar, and quartz gravels; slight sticky, slightly plastic; acid; abrupt smooth boundary.

Acg--11 to 19 inches; very dark grayish brown (10YR 3/2), broken, silty clay loam; strong medium and coarse granular structure; firm, sticky, plastic; very few very fine roots; common medium tubular pores; common medium irregular black (10YR 2/1), broken, manganese nodules and many coarse irregular yellowish brown (10 YR 5/6), broken, iron nodules; few fine flakes of mica; slightly acid; gradual wavy boundary.

Btl--19 to 40 inches; yellowish brown (10YR 5/6), broken, silty clay; many coarse prominent gray (10YR 5/1), broken, redox depletions on ped faces and in root channels; moderate medium and coarse prismatic parting to moderate coarse platy structure; firm, sticky, plastic; very few very fine roots in pores; many very fine and common medium and coarse tubular pores; many distinct very dark grayish brown (10YR 3~2), broken, clay films on faces of peds; many coarse irregular black (10YR 2/1), broken, and dark gray (N 4~0), broken, manganese nodules and common coarse irregular yellowish red 5YR 4/6), broken, iron nodules; few fine flakes ofmica; diffuse smooth boundary.

Bt2--40 to 60 inches; yellowish brown (10YR 5~6), broken, clay loam; many coarse prominent light gray (N 6/0), broken, redox depletions on ped faces and in root channels; moderate medium and coarse prismatic parting to weak coarse and very coarse platy structure; varve planes; in prisms; friable sticky, plastic; very few very fine roots; many very fine and common medium and coarse tubular pores; many distinct very dark grayish brown (10YR 3/2), broken, clay films on vertical faces of peds and in root channels; common coarse irregular strong brown (7.5YR 4/6), broken, manganese coatings and yellowish red (5YR 4/6), brokenl iron nodules; few fine flakes of mica; neutral; clear smooth boundary.

C--60 to 80 inches; dark yellowish brown (10YR 4/4), broken, and light brownish gray (10YR 6~2), broken, loam; massive; friable, slightly sticky, slightly plastic; common fine vesicular pores; common medium irregular very dark gray (N 3/0), broken, manganese nodules; common fine flakes of mica; neutral.

Remarks: This profile description was written by Dr. William Edmonds and Dr.

Pamela Thomas of the Crop and Soil Environmental Sciences Department in August 1992. The description was taken from an excavated pit in a fescue grass buffer zone.

Table 1 - - McGary silt loam Groundwater Data Table
January - June, 2000 (155 Days)
Kentland, Data Logger Well # 1

Well # 1

Depth Range (in.)	Number of Days	Percent Time	Percent Cumulative Days	Cumulative Days
0-6	1	1	1	1
6.1-12	4	3	5	3
12.1-18	7	5	12	8
18.1-24	8	5	20	13
24.1-30	7	5	27	17
30.1-36	13	8	40	26
36.1-39	55	35	95	61
39.1-42 (Dry)	59	38		

Table 2 - - McGary silt loam Groundwater Data Table
July - December, 2000 (184 Days)
Kentland, Data Logger Well # 1

Well # 1

Depth Range (in.)	Number of Days	Percent Time	Percent- Cumulative Days	Cumulative Days
0-6	1	1	1	1
6.1-12	1	1	2	1
12.1-18	3	I	5	3
18.1-24	5	2	10	4
24.1-30	3	I	13	8
30.1-36	5	2	18	11
36.1-40	24	15	42	23
40.1-41 (Dry)	142	77		

Number of Days column refers to the number of days the surface of the free water was present within the depth range.
Percentage of Time column refers to the percent of time the water was present within the depth range.
Cumulative Days column refers to the total number of days the water was present within the depth range.
PerCentage of Cumulative Days refers to the percent of total time the water was present within the depth range.

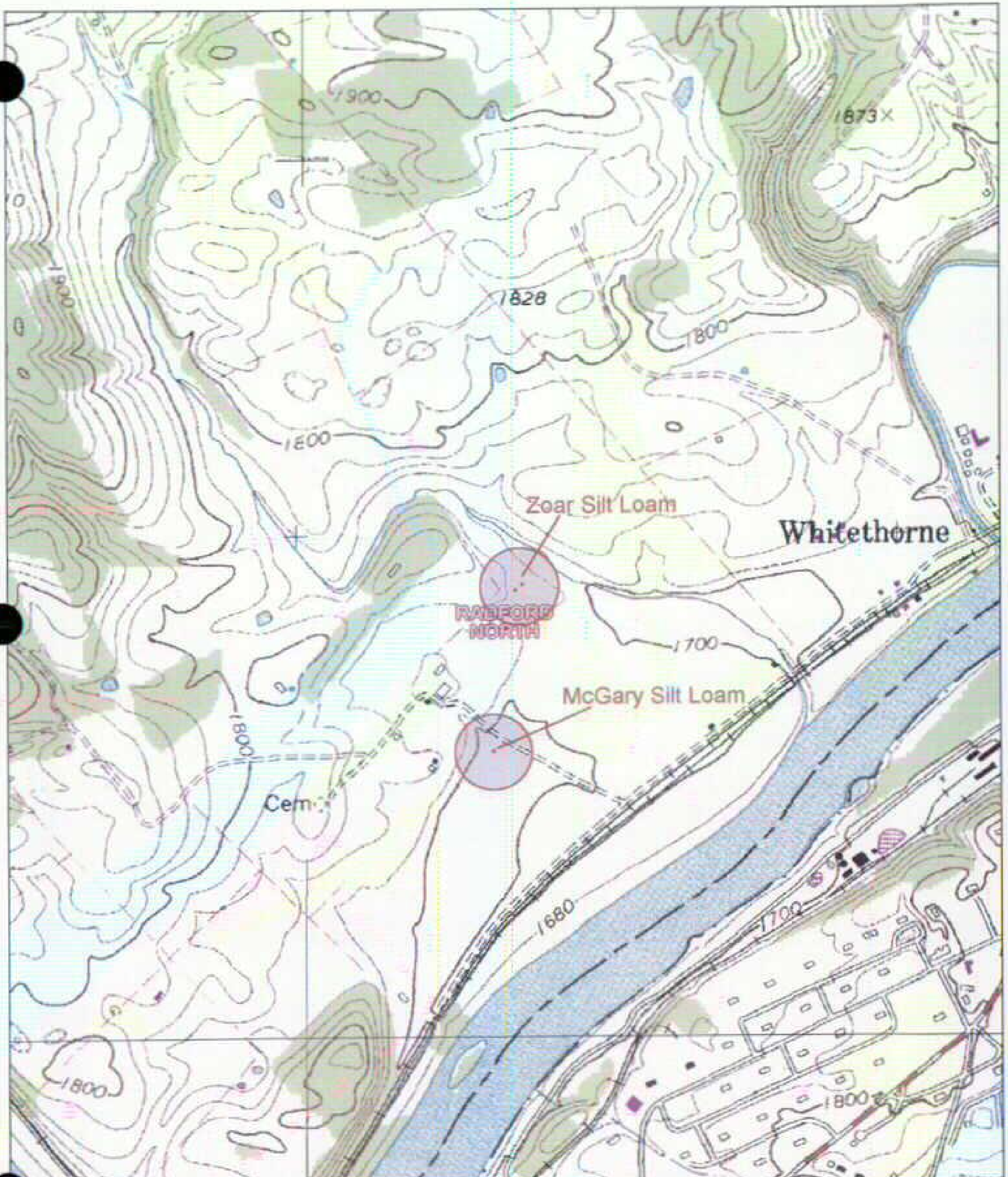
DRY corresponds to the number of readings (converted to days) where the monitoring well recorded no water in the hole.'
Days in the column headings corresponds to the number of data logger readings within a depth range divided by the number (normally 2, 4 or 8) of data logger readings perday.

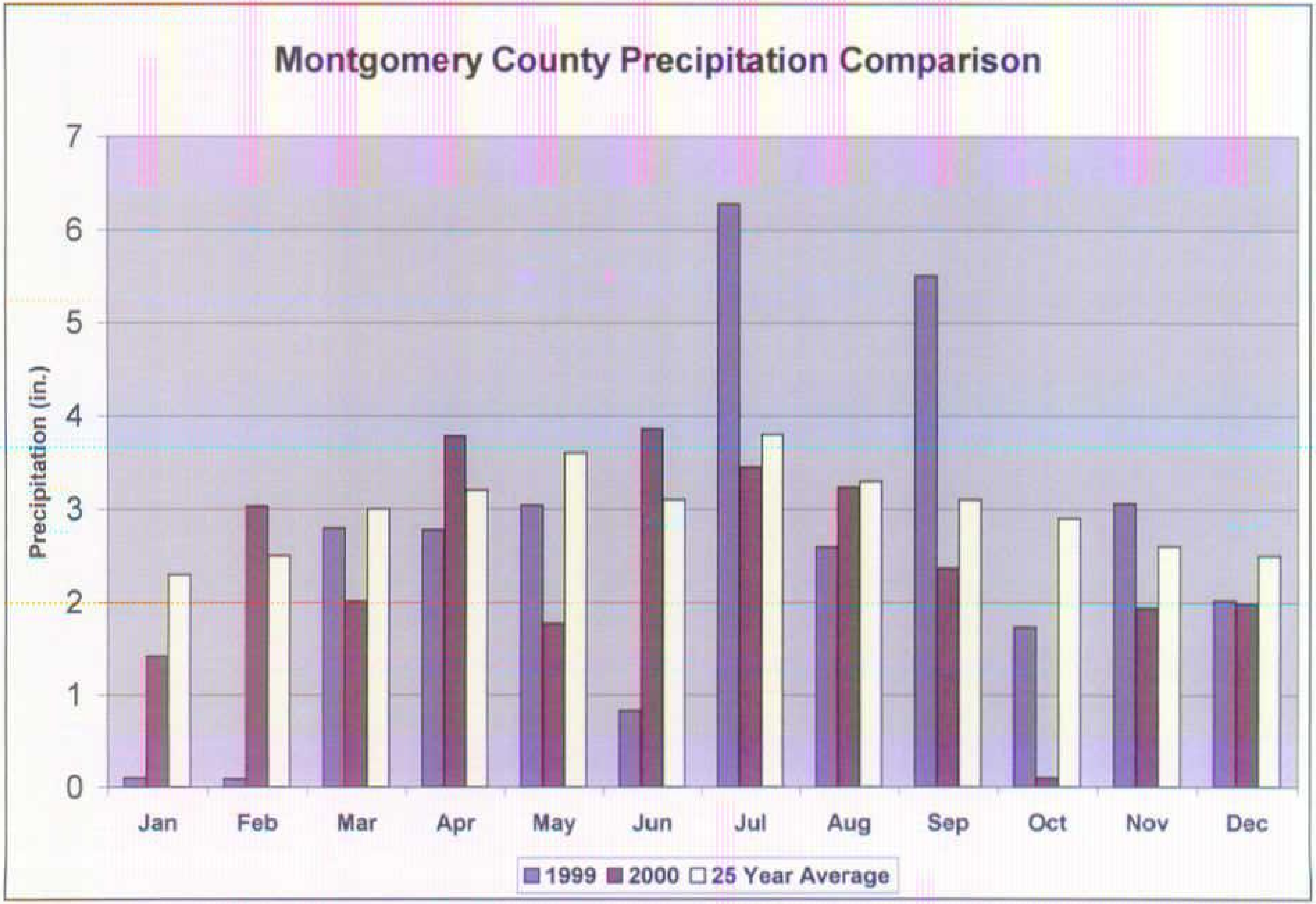
Table 1 - - McGary silt loam Groundwater Data Table
January - April, 2001 (93 Days)
Kentland, Data Logger Well # 1

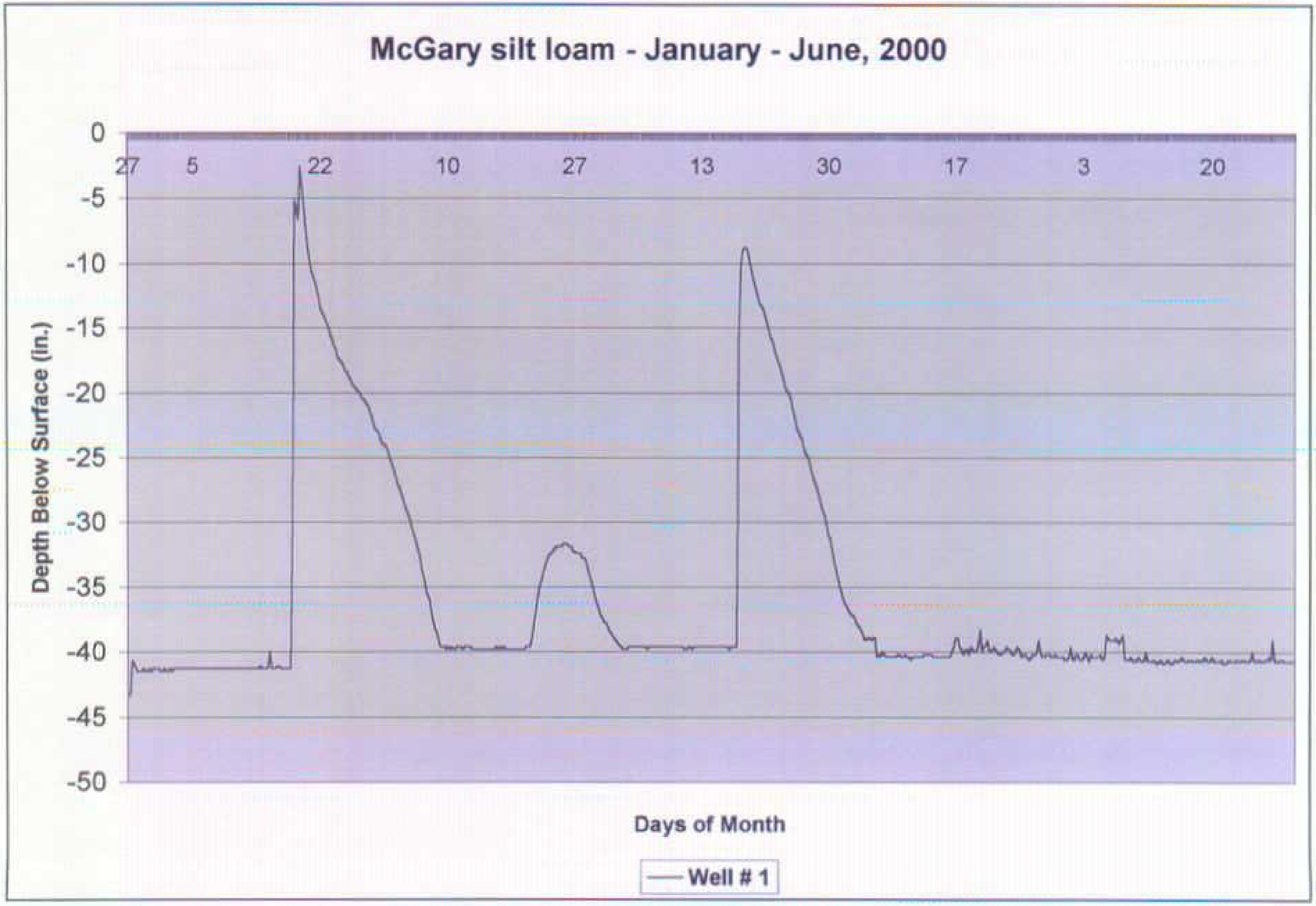
Well # 1

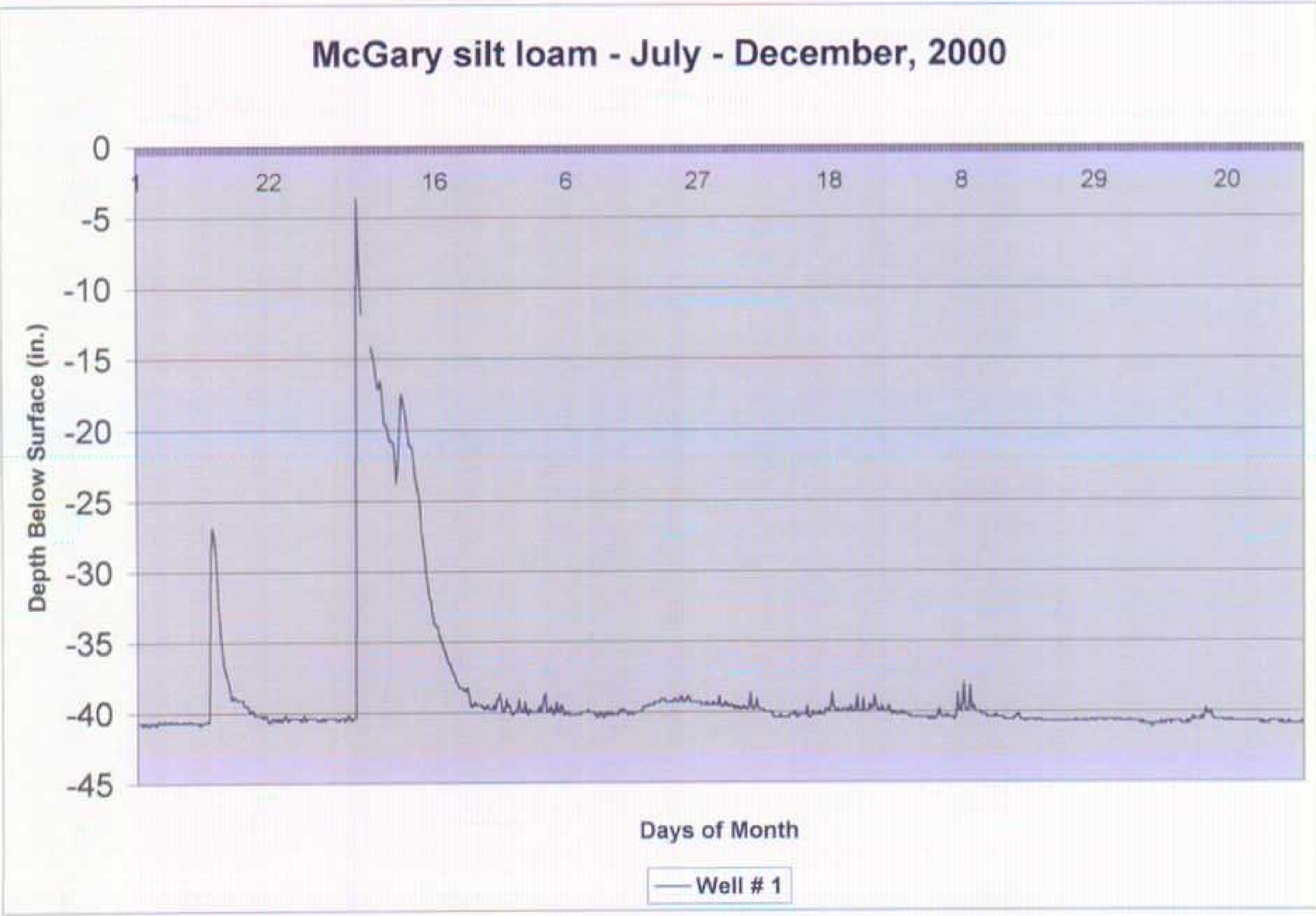
Depth Range (in.)	Number of Days	Percent Time	Cumulative Days	Percent Cumulative Days
0-6	3	3	3	3
6.1-12	2	2	5	4
12.1-18	4	4	9	10
18.1-24	9	10	18	19
24.1-30	5	5	23	26
30.1-36	14	15	37	42
36.1-39	22	24	59	63
39-42 (Dry)	34	37		

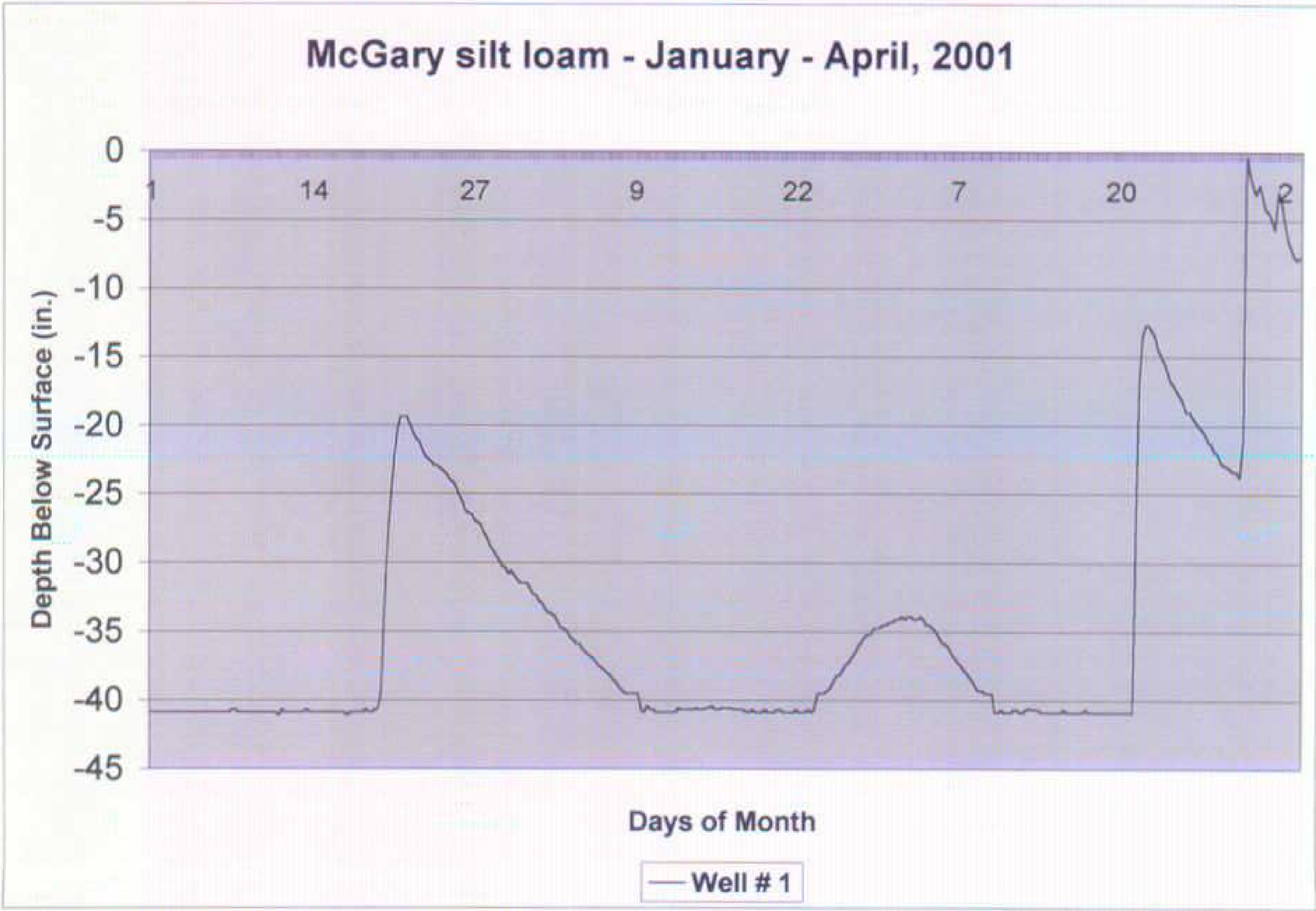
Number of Days column refers to the number of days the surface of the free water was present within the depth range.
Percentage of Time column refers to the percent of time the water was present within the depth range.
Cumulative Days column refers to the total number of days the water was present within the depth range.
Percentage of Cumulative Days refers to the percent of total time the water was present within the depth range.
DRY corresponds to the number of readings (converted to days) where the monitoring well recorded no water in the hole.
Days in the column headings corresponds to the number of data logger readings within a depth range divided by the number (normally 2, 4 or 8) of data logger readings per day.


1900
1873
1828
1800
Zoar Silt Loam
Whitethorne
RADFORD NORTH
1700
McGary Silt Loam
1800
Cem
1680
1700
1800
1800
1725


Montgomery County Precipitation Comparison
Precipitation (in.)
0
1
2
3
4
5
6
7
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
1999
2000
25 Year Average


McGary silt loam - January - June, 2000
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
Depth Below Surface (in.)
27
5
22
10
27
13
30
17
3
20
Days of Month
Well # 1


McGary silt loam - July - December, 2000
Depth Below Surface (in.)
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
1
22
16
6
27
18
8
29
20
Days of Month
Well # 1


McGary silt loam - January - April, 2001
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
Depth Below Surface (in.)
1
14
27
9
22
7
20
2
Days of Month
Well # 1

SOIL EVALUATED: Nason-like silt loam

LOCATION:

The study site is in northwest Spotslyvania County, Virginia. Refer to the accompanying portion of the U.S. Geological Survey topographic map for the general topography and landforms. The accompanying site sketch shows the location of the automated data logger and two manual monitoring wells in a small patch of woods in an established residential subdivision.

RATIONALE FOR SITE SELECTION:

The Piedmont soils in the general area have developed in mostly residual soil materials weathered from sericite and graphite schist. The soils with yellowish brown to red Bt horizons are generally acknowledged to be well drained based on their oxidized subsoil colors. Determining suitability for a septic system drainfield in these red to brown soils is fairly straightforward. However, the soils with a high component of graphite schist and dominantly gray subsoil colors make determination of drainfield suitability much more difficult. The olive and gray graphite schist colors in the Bt and C horizons may be masking seasonal watertable and soil wetness features. It is difficult to attain a high and consistent level of comfort when ,evaluating these soils for drainfield suitability

-' because of the dominantly gray parent material colors. Finally, the three monitoring wells are close to a conventional septic system drainfield and the watertable data may 'be used to determine how well the drainfield can function in the graphite rich soils.. 'i'

SOIL AND SITE INFORMATION:

The soils at the study site have formed mostly in residuum Weathered from graphite and sericite schist/phyllite parent materials. The study site is in a very small, reCtangular Shaped patch of open hardwoods left natural for Chesapeake Bay watershed rules and esthetic purposes. The soils are on a nearly level to gently sloping summit and slopes range from 0 to 7 percent over the general study area. The study site is contained within a residential lot that has an existing house, conventional drainfield, and drilled well, all of which were constructed in 1999-2000.

The Soil Survey of Spotsylvania COunty, Virginia (J.H. Elder, Jr., 1985) has the general study site mapped as 32B: Nason silt loam, 2 to 7% slopes; or 32C2: Nason silt loam, 7 to 15% slopes eroded. The study site definitely fits better in the 32B map unit. (Note: subdivision road building and lot clearing have altered the general area someWhat, and study site location is not precise.) According to the Soil Survey, the Nason soil is deep and well drained and has moderate permeability. It is classified as a fine, mixed, semiactive, thermic Typic Hapludult.

A detailed soil profile description was made at the site from a hand auger boring. When compared to the offidal soil series description for the Nason soil (refer to the Appendix), the soil at the study site has Bt horizon colors that are more olive and grayer than the typical Nason soil. Typical Nason Bt colors are yellowish red (5YR), strong brown (7.5YR), or yellowish brown (10YR). The Nason-like soil has Bt horizons that are olive brown (2.5Y) and gray. The gray colors are inherited from the graphite schist parent material. These color differences are minor and use and management of the Nason soil is similar to the Nason-like soils.

. CLIMATIC DATA FOR THE SITE:

The Nason-like study site is near Chancellorsville, which is about six miles west of Fredericksburg. Weather data from the Fredericksburg Sewage' Plant (1999, 2000, and 2001) and the Fredericksburg National Park (29-year average) were used to provide yearly and monthly precipitation figures for the study site. The precipitation comparison graph for Spotsylvania County shows how each months precipitation total compares to the monthly 29-year averages (1961-1990).

· During the November-December 1999 study period, precipitation was below normal. In fact, precipitation was only about 62% of the long-term average for the two month span. Also, many parts of Virginia were experiencing severe drought conditions during 1999. With these dry conditions, it would be expected that Watertable levels in the soils would be Iow or absent.

During the January-June 2000 study period, total precipitation was about 5 inches above the 29-year average of 20.05 inches. In June, rain totaled 9.74 inches, which is almost 3 times the 29-year average of 3.37 inches.

During the July-December 2000 study period, total precipitation was about 3 inches aboVe the 29-year average of 20.8 inches. Of note, only 0.05 inches of rain was recorded for October. This dry month anomaly only serves to emphasize how remarkably well annual precipitation is distributed in Virginia.

For the study period from January-May 2001 (Nason-like watertable monitoring ended on 5-25-01), total precipitation was only 2 inches less than the 29-year average of 16.68 inches.

For the general study period beginning November 1999 and ending May 2001, total precipitation was about normal as compared to the 29-year average. The major exceptions were the relatively dry conditions near the end of 1999, and the months of June, July, and September in 2000 when a total of 26.85 inches of rain was recorded as compared to the 29-year average for these months of 10.68 inches. These'three very wet, episodic months should be reflected in the measured watertables at the study site, though the summertime high levels may be very transient.

RESULTS:

An automated (WL-40) data logger, a 24-inch manual, and a 60-inch manual well were installed in the Nason-like soils. The wells were in a small wooded area and are 5 to 10 feet apart. The one described soil profile represents the general soil features and properties for the three wells. All wells are on the same nearly level to gently sloping summit. A large retention basin is slightly downslope from the study site, but it does not appear that it had much effect on the watertables in the soils. Also, the existing drainfield located nearby on the same gently sloping landform appears to have had minimal, if any, effect on measured watertables. Continuous automated data collection began on NOvember 18, 1999. The manual wells were read only when visiting the study site to download data from the data logger. The manual wells were not intended to gather watertable data on a frequent basis, instead they were used mostly as a check to see how close the data logger and manual wells corresponded.

Prior to the watertable study it was difficult to predict what the measured watertables would be in the Nason-like soil with its dominantly gray and olive brown colors in the subsoil and substratum horizons. A previous feasibility evaluation of the soils in the proposed subdivision had determined that the soils varied quite a bit in color, based on the content of graphite schist. 'Several dozen backhoe pits were used by a private soil-consulting firm to establish soil suitability for septic system drainfields. Soils with a high content of graphite were interspersed randomly with the typical redder and browner Nason soils, all on the same landform. The Spotsylvania County Health Department eliminated a few of the proposed drainfleld sites during the subdivision review process because of unsuitable landscape positions (generally sites that encroached into Piedmont upland drainageways.)

The water table hydrograph and the Groundwater Data Table for November-December 1999 indicates the 40-inch monitoring well was dry for the 44-day period. The dry well somewhat reflects the drought conditions that were present in much of Virginia during 1999. During October-November-December 1999, total precipitation was 6.34 inches as compared to the 29-year average of 10.01 inches. The fact that no watertable levels were recorded in November-December 1999 as opposed to other months that had significant watertable levels does appear to indicate the natural watertable via groundwater recharge had been Iow for an extended period.

The watertable hydrograph for Nason-like during January-June 2000 shows the watertable fluctuated between 14 to 40 inches below the soil surface. A big but gradual drop in the free water level starting in early May coincides with tree leafing-out and a rapid increase in evapotranspiration at the site. During June there were wild swings in the watertable levels. Pronounced highs were quickly followed by pronounced ,lows. These swings correlated well with the extremely high rainfall total of 9.74 inches for

June. Watertables in June peaked at 9 inches below the soil surface and dropped to a Iow of 33 inches. The dramatic but short lived highs and lows seem to indicate that watertables can build up quickly in the Nason-like soil, but the graphite soil materials are sufficiently permeable to allow for quick drops in the watertable levels.

The January-June Groundwater Data Table for the Nason-like soil shows that free water levels were recorded between depths of 6 to 40 inches for at least 134 days, or 73% of the time. No water was observed in the A and E horizons; in some part of the Bt1 and Bt2 horizons free water was present for 19 days or 10% of the time; for the Bt3 horizon free water was measured for at least 118 days or 65% of the time. There were 48 dry days measured which was 26% of the 182-day .span.

The depth range from 18 to 24 inches had the highest number of watertable recordings at 39 days, or 21 percent of the time. The next highest number was 38 days in the 24 to 30 inch depth range. Combined days of wetness in the 18 to 30 depth range was 77 days which is almost 1/2 of the time.

The July-December 2000 hydrograph shows several spiking trends followed by many days of dry wells. July was a major exception to this, as it experienced the same extreme highs and lows similar to June 2000. During July, the watertable ranged from 9 to 36 inches in the Nason-like soil. The extreme fluctuations correlate well with the Very high rainfall recorded for July of 8.85 inches, which was much greater than the 29-year average of 3.71 inches.

The same pattern occurred in September but with only one big spike. From mid August to mid September the well was dry (no water in the well too at least 41 inches). Near the end of September the watertable rose to 15 inches within two days; however, within nine days the well was dry. The extreme spike correlates well with the 8.26 inches of rain in September, which was well above the 29-year average of 3.60 inches. In October only 0.05 inches of rain fell. November and December each had one big spike in the watertable where the level rose to 17 inches in November and 13 inches in December. There is not a good correlation in watertable level and rainfall. Combined precipitation in November and December was 3.26 inches compared to the 29-year average of 6.55 inches.

The Nason-like Groundwater Data Table for July-December 2000 shows that free water was measured in some part of the soil from 6 to 40 inches a total of 106 days, or 58% of the time. No water was measured in the A and E horizon; the Bt1 and Bt2 had water '9 days or 5% of the time; and the Bt3 had free water for 81 days or 44% of the time. There were 78 days of a dry well, which was 42% of the time.

The January-May, 2001 hydrograph shows the Nason-like soil had a watertable during the entire study span. In mid January the watertable spiked from 35 inches below the soil surface to 10 inches. In February the watertable fluctuated between 13 to 18 inches below the soil surface. Normally, the watertable was expected to be somewhat higher, or at least similar to other wet winter months when evapotranspiration was at a minimum and total precipitation can include snow and rain. Total precipitation for

January-February 2001 was 4.03 inches, as compared to the 29-year average of 6.19 inches. Therefore, February started with a groundwater deficit.

From the end of February to eady May the watertable fluctuated mostly between 10 to 15 inches below the soil surface. March had two spiking events where the watertable rose rapidly to 3 to 4 inches from the surface. March precipitation was 4.01 inches, which was slightly above the 29-year average of 3.52 inches.

April watertable fluctuations were minimal and hovered around 10 to 12 inches below the soil surface. It is hard to account for the high April watertable levels, since rain for April was 1.46 inches versus 3.12 inches for the 29-year average. In May, it is easier to account for the gradual drop from 12 inches to 26 inches because of trees leafing out and increasing evapotranspiration. May had the highest watertable spike of any month in the January-May 2001 period. About May 21, the watertable rose rapidly to 2-3 inches below the soil surface in one day; it also dropped back to 15 inches below the surface in essentially the same day. A significant rainfall event had to produce these narrowly ranged up and down watertable spikes. Rain was 5.23 inches for May, which is a little above the 29-year average of 3.85.

Note: It must be remembered that total precipitation recorded for any month in the entire study period is just that, total precipitation. We have not reported the distribution of precipitation for any month, of which any significant rainfall event could result in pronounced spikes in the watertable. As an example, rainfall for June 2000 was 9.74 inches. It is possible and probable that much of the total rainfall for June may have occurred in just a few significant rainfall-events. The best example of this is the occasional tropical storm that sweeps through Virginia in the hurricane season.

The January-May 2001 Groundwater Data Table. shows that free water was measured in 'some part of the soil from 0 to 40 inches for 145 days, or 100% of the time. The ^ and E horizons had free water for one day; the Bt1 and Bt2 horizons had free water for 86 cumulative days, or 58% of the time; and the Bt3 had free water for 143 days, or 97% of the time. There were no dry days recorded.

The 12.1-18 inch depth range had the most watertable recordings at 48 days, or 33% of the 145 day study period. Next was the 18.1-24 inch depth range with 38 days, or 26% of the time, and then the 6.1-12 range with 36 days, or 25% of the time.

The Nason-like soil consistently stayed wet in some part of the soil for 145 days. Between 6 to 24 inches below the soil surface, free water was measured for 122 days, or 83%'of the time. The consistentlY high watertable can not be closely tied to total precipitation for the January-May 2001 study period. In fact, precipitation for the pedod was only 14.73 inches, as compared to the 29-year average of 16.68 inches. The fact that the Nason-like soil never "dried out" seems to indicate that the watertable was. constantly being recharged via a larger landscape unit, and not recharged from local rainfall events.

CONCLUSIONS:

The Nason-like soil stayed wet for long periods of time and measured watertable levels were higher in the profile than Soil than soil features would indicate. Because the grayish and olive brown matrix color of the soil is mostly inherited from the graphite schist parent material, predictive soil wetness features and indicators used to evaluate suitability for drainfields are commonly masked. Precipitation throughout the study period was generally close to,normal, though in late 1999 many parts of Virginia were experiencing drought conditions. The Nason-like soil experienced enough "normal'" precipitation during the study period to allow for natural watertables to occur in the soil. The total study period ran 555 days.

When depth ranges are grouped together to generally correlate with the horizon depths described in the Nason-like soil, it can be seen that the A and E horizons (0 to 6 inches) had free water present only one day during the entire study period. This lack of free water right below the soil surface was to be expected, based on the overall drainage of the soil and the slightly convex summit the study site is on.

The Bt1 and Bt2 horizons (6 to 18 inches) had free water in them for a total of 112 days, or 20% of the time. Groundwater at these shallow depths in the soil would have a major impact on drainfield suitability and performance. Virginia Sewa,qe Handlin.q and Disposal Re,qulations (2000) mandate that a conventional septic system drainfield be · installed at a depth of 18 inches or more below the soil surface. Then, the Regulations require an 18-inch separation distance from trench bottom to significant soil limitations such as a watertable, bedrock, or impervious horizon. Therefore, a typical soil site using a conventional septic system drainfleld will require 36 inches of Suitable soil. Onsite wastewater treatment and disposal systems that pretreat the septic effluent using various media and filters allow for placement of the system lines or trenches at depths less than 18 inches, and also require only a 12-inch standoff from trench bottom to significant soil limitations.

The Bt1 and Bt2 horizons in the Nason-like soil do not have any major morphological features to indicate that free water in the soil would occur as it did. The matrix colors are light olive brown and yellowish brown and no mottles were described. Two extremes were noted: November-December 1999 had no free water in the profile, while January-May 2001 had free water in some part of the profile everyday. This seems to suggest that the Nason-like soil over the seasonal cycles does."dry out," with the watertable dropping below 40 inches at least (monitoring well did not measure below 40 inches). In addition, the study suggests that once this Nason-like soil gets wet during winter and spring, its watertable may remain constant and be more dependent on overall recharge within the local watershed and drainage basin, instead of individual rain events. During one site visit to the Nason-like soil, the newly constructed drilled well had free water coming out of the well top or overflow port.

The Bt3 horizon (roughly 24 to 36 inches) had the surface of free water measured in it for a total of 137 days, or 24% of the study period. (Note: It must be pointed out that when the surface of the watertable was in one of the upper horizons, the lower horizons, such as the Bt3, were also generally wet, especially for the purposes of this soil study. But there are common enough situations, especially in a fall-line county such as Spotsylvania, where the upper part of the soil can be wet and the underlying part of the soil is dry or relatively dry. An example of this is a Coastal Plain capping soil that has a watertable, while the underlying residual Piedmont saprolite does not. Still for the drainfield program, any soil and site evaluation would always be concerned about any watertable, high or Iow.

The Nason-like soil was dry (to at least 40 inches below the soil surface) for 170 days, or 31% of the time. The very rapid spikes and drops in the watertable measured in this soil also Seem to indicate that permeability and internal drainage are generally good. This is based on the watertable levels that rose precipitously in a day or two, and then dropped equally precipitously in a day or two. The exception to the permeability trend was the January-May 2001 span.

In summary, the study site soil is Nason-like and not all Nason soils will have a similar watertable. In fact, the Nason soil is well drained. However, the Nason-like soil does show that any soil with Bt horizons with a high enough content of graphite schist to color the soil gray and olive brown should be evaluated extra carefully. This would include looking for any pale mottles in the drab colored E and Bt horizons; evaluating the graphitic soils only with a backhoe pit to lessen the overall smearing and churning of the soil colors when using a hand auger; and if in doubt about overall wetness in the soil, do a watertable study. As a minimum, return to the site several times over the course of a few weeks to see how wet the site is. With the grayish parent materials potentially masking seasonal wetness, it is imperative that any potential drainfield site in this type of soil avoid marginal landscape positions.

There are disparities in the data logger versus manual well readings table, though all three monitoring wells are at different depths. There are enough close readings when the soils are really wet or really dry to show some reasonable correlation between the high-tech and Iow-tech monitoring methods.

Nason-like silt loam

Soil Profile for Well # 1 (WL-40); 24-inch Manual Well; and 60-inch Manual Well
A--0 to 2 inches; very dark grayish brown (10YR 3/2) and grayish brown (10YR 5/2) silt loam; friable, non sticky, non plastic; 2 to 10% quartz gravel.

E--2 to 7 inches; light olive brown (2.5Y 5~4) loam; few medium light brownish gray (2.5Y 6/2 to light yellowish brown (2.5Y 6/3) mottles; friable, non sticky, non plastic; 2 to 10% quartz gravel. 0

Bt1--7 to 11 inches; light olive brown (2.5Y 5/6) to yellowish brown (10YR 5/6) loam; friable, slightly sticky, slightly plastic; 5 to 10% quartz gravel.

Bt2--11 to 21 inches; light olive brown (2.5Y 5/6) to yellowish brown (10YR 5/6) heavy loam; firm, slightly sticky, slightly plastic; 5 to 15% quartz gravel.

Bt3--21 to 35 inChes; mottled light olive brown (2.5Y 5/6), yellowish brown (10YR 5/8) and gray (2.5Y 6~0) clay loam to silty clay loam; firm, slightly sticky, slightly plastic; gray colors related to graphite schist parent material; many very fine mica flakes; 5 to 15% angular to subangular quartz gravel.

Bt4--35 to 48 inches; mottled light olive brown (2.5Y 5/4), gray (2.5Y 6/0), and yellowish brown (10YR 5/8) heavy loam; firm, slightly sticky, slightly plastic; gray colors related to graphite schist parent material; many very fine mica (sericite) flakes; 5 to 15% angular to subangular quartz gravel.

BCt--48 to 60 inches; gray (2.5Y 6/0) heavy loam; many yellowish brown (10YR 5/6) and light olive brown (2.5Y 5/4) mottles; firm, slightly sticky, slightly plastic; 5 to 10% angular vein? quartz gravel.

Remarks: Profile is described from a hand auger boring. The landform is a gently sloping (2 to 7% slopes) Piedmont summit. The monitoring wells are in a small rectangular shaped patch of woods that are left after most of the lot has been cleared for residential construction. Soils in the general area are mostly Nason along with grayer soils that have a high content of strongly weathered, soft graphite schist material. Soils in area have some transported features in upper parts of the profile.

Table I ' Nason-like silt loam Groundwater Data Table
November- December, 1999 (44Days)
Chancellorsville, Data Logger Well # 1 (WL-40)

- Well # 1

Depth Range (in.)	Number of Days	Percent Time	Cumulative Days	Percent Cumulative Days
0-6	0	0	0	0
6.1-12	0	0	0	0
12.1-18	0	0	0	0
18.1-24	0	0	0	0
24.1-30	0	0	0	0
30.1-36	0	0	0	0
36.1-40	0	0	0	0
DRY	44	100	44	100

Table 2 - - Nason-like silt loam Groundwater Data Table
January- June, 2000 (182 Days)
Chancellorsville, Data Logger Well # 1 (WL-40)

Well # 1

Depth Range (in.)	Number of Days	Percent Time	Cumulative Days	Percent Cumulative Days
0-6	0	0	0	0
6.1-12	1	I	1	1
12.1-18	18	10	19	10
18.1-24	39	21	58	32
24.1-30	38	21	96	53
30.1-36	22	12	118	65
36.1-40.7	16	9	134	73
DRY	48	26	182	100

Number of Days column refers to the number of days the surface of the free water was present within the depth range.
Percentage of Time column refers to the percent of time the water was present within the depth range.
Cumulative Days column refers to the total number of days the water was present within the depth range.
Percentage of Cumulative Days refers to the percent of total time the water was present within the depth range.

DRY corresponds to the number of readings (converted to days) where the monitoring well recorded no water in the hole.
Days in the column headings corresponds to the number of data logger readings within a depth range divided by the number (normally 2, 4 or 8) of data logger readings per day.

Table 3 - - Nason4ike silt loam Groundwater Data Table
July-December, 2000 (184 Days)
Chancellorsville, Data Logger Well # 1 (WL-40)

Well # 1

Depth Range (in.)	Number of Days	Percent Time	Cumulative Days	Percent Cumulative Days
0-6	0	0	0	0
6.1-12	1	1	1	0
12..1-18	8	4	9	5
18.1-24	15	8	24	13
24.1-30	22	12	46	25
30.1-36	35	19	81	44
36.1-40	25	14	106	58
DRY	78	42	184	100

Table 4 - - Nason-like silt loam Groundwater Data Table
January-May, 2001 (14S Days)
Chancellorsville, Data Logger Well # 1 (WL-40)

Well # 1

Depth Range (in.)	Number of Days	Percent Time	Cumulative Days	Percent Cumulative Days
0-6	1	1	1	1
6.1-12	36	25	38	26
12.1-18	48	33	86	58
18.1-24	38	26	123	'83
24.1o30	3	2	126	85
30.1-36	17	12	143	97
36.1-40	2	I	145	100
DRY	0	0	0	0

Number of Days column refers to the number of days the surface of the free water was present within the depth range.
Percentage of Time column refers to the percent of time the water was present within the depth range.
Cumulative Days column refers to the total number of days the water was present within the depth range.
Percentage of Cumulative Days refers to the percent of total time the water was present within the depth range.

DRY' corresponds to the number of readings (converted to days) where the monitoring well recorded no water in the hole.
Days in the column headings corresponds to the number of data logger readings within a depth range divided by the number (normally 2, 4 or 8) of data logger readings per day.

"Table 5 - Nason-like - Days Surface of Free Water Measured in Depth Range (555 Days)

Depth Range (in.)	Nov-Dec 99	Jan-Jun 00	Jul-Dec 00	Jan-May 01	Total Days	% Total Days
0-6	0	0	0	1	1	0
6.1-12	0	1	1	36	38	7
12.1-18	0	18	8	48	74	13
18.1-24	0	39	15	38	92	17
24.1-30	0	38	22	3	63	11
30.1-36	0	22	35	17	74	13
36.1-40	0	16	25	2	43	8
DRY	44	48	78	0	170	31

** For other soils in the study, this table is generally described in the narrative.

Table 6 - Nason-like Automated versus Manual Watertable Readings

Date	Data Logger (in)	Manual Well (24 in)	Manual Well (60 in)
11-18-99	Dry	Dry	Dry
01-17-00	Dry	Dry	Dry
02-03-00	Dry	Missing	Missing
04-05-00	22.4	Dry	Dry
05-04-00	21.0	Missing	Missing
07-07-00	24.0	Dry	Dry
10-10-00	Dry	Dry	Dry
12-05-00	34.1	Dry	Dry
01-23-01	. 16.4	14	59
03-15-01	'13.5	16	24
04-30-01	11.3	22	20
05-25-01	16.0	21	50

Spotsylvania County Water Table Monitoring Sites

not to scale

All monitoring wells are
about 5 to 10 feet apart.

Existing House

Subdivision Road (paved)

Wooded ~drilled well
73'

Nason Soil ,'
Well # 1
New House 40 inch datalogger

Drainfield
I
.ason S0il ~ /
· we, # 2 - / | , / Wooded
24 inch manual well · / / ·
/
/
' / Nason Soil
I
9(~' Well#3 ~ ~ °

60 inch manualwelll ~ /

!

R~taining Pond

Spotsylvania County Water Table Monitoring Sites

not to scale

All monitoring wells are
about 5 to 10 feet aparL

Existing House

Subdivision Road (paved)

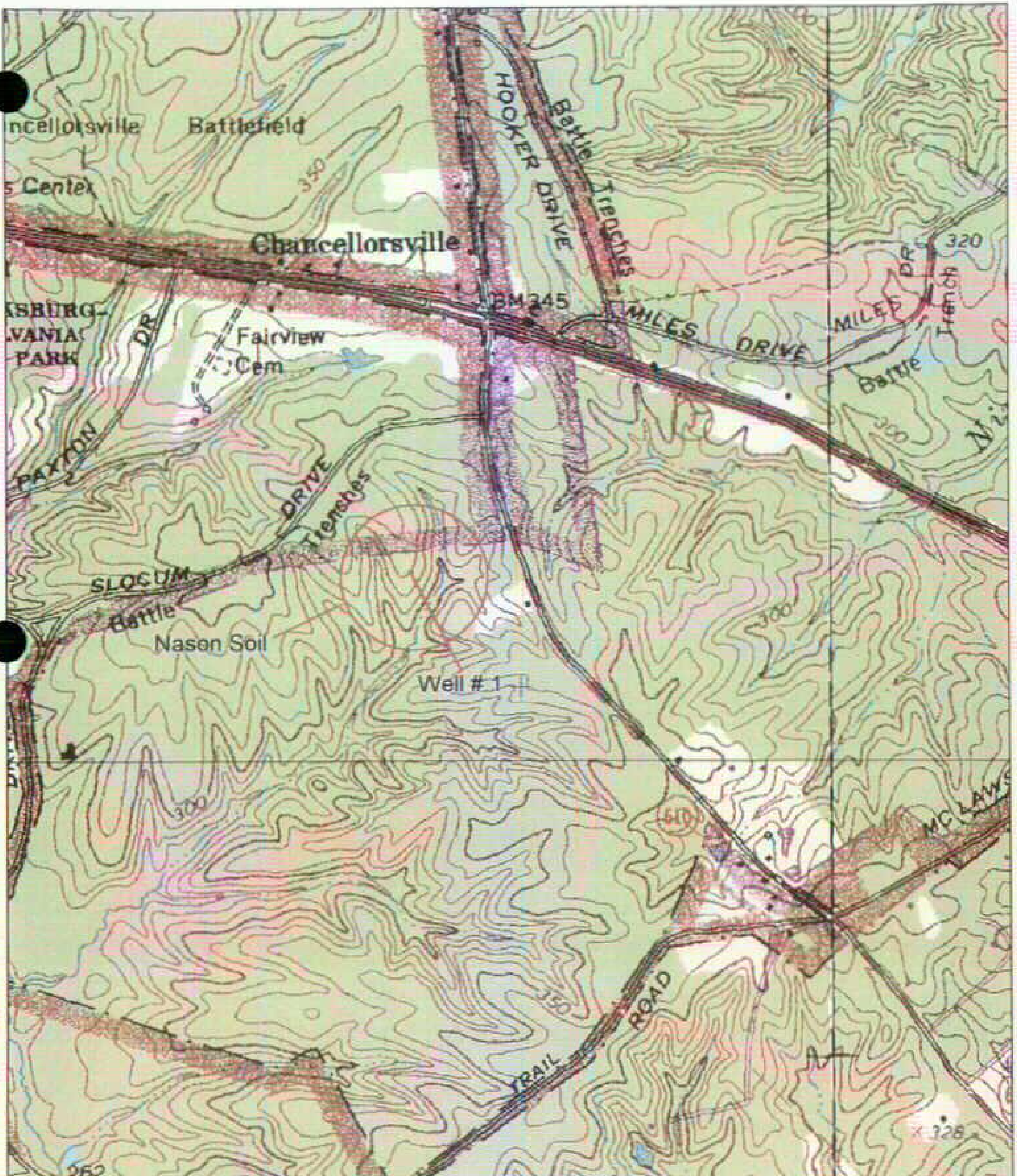
?$' Wooded~ ~drilled
well

/
Nason Soil
Well # 1
New House 40 inch datalogger (~= 54'

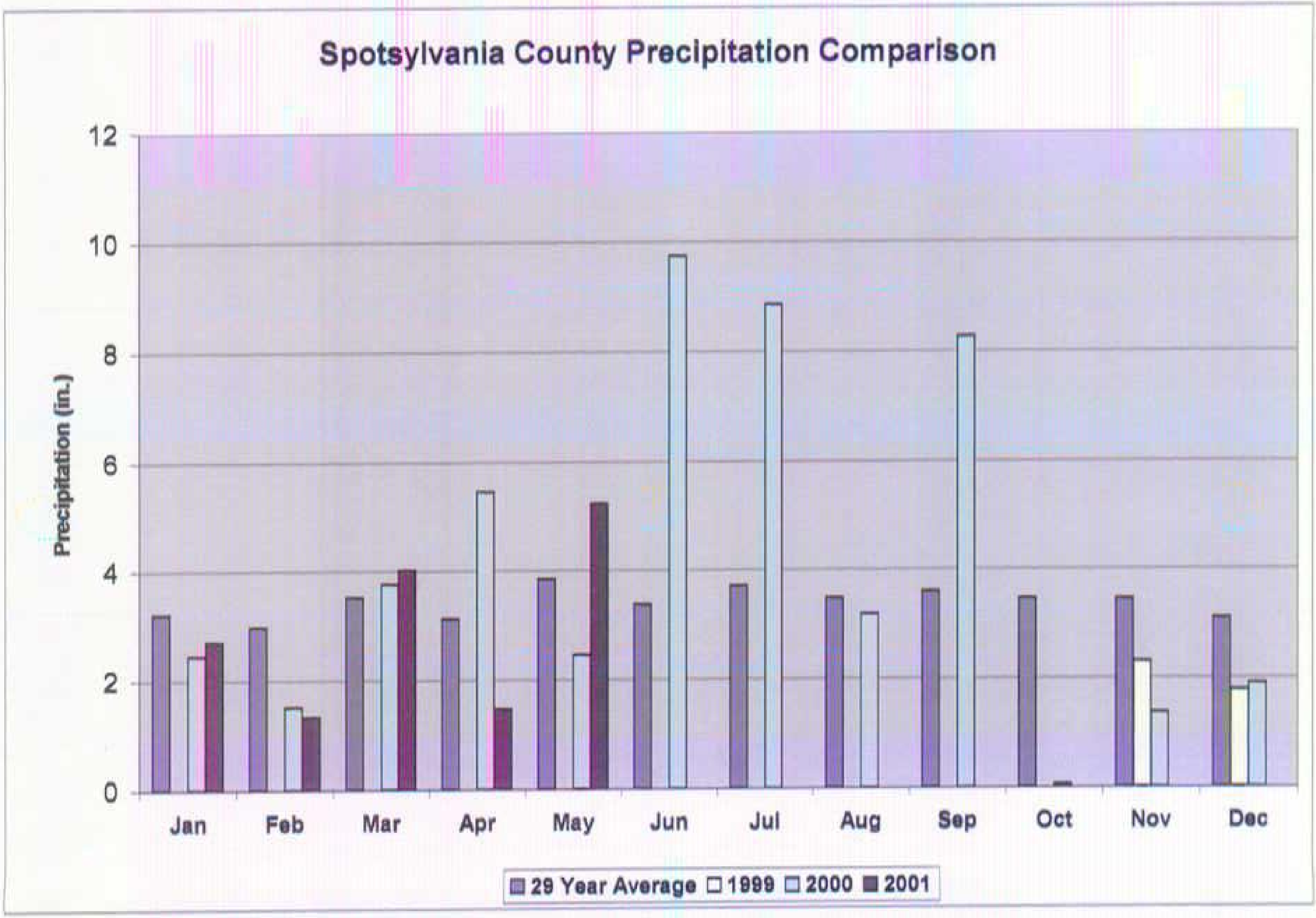
Drainfield

.aeon soi~~ / ~ ' ~ / Wooded
24inchmanualwell / [1~'
/ Nason Soil
9~' Well # 3 .
60 inch manual well j /

/
• R~taining ~ond

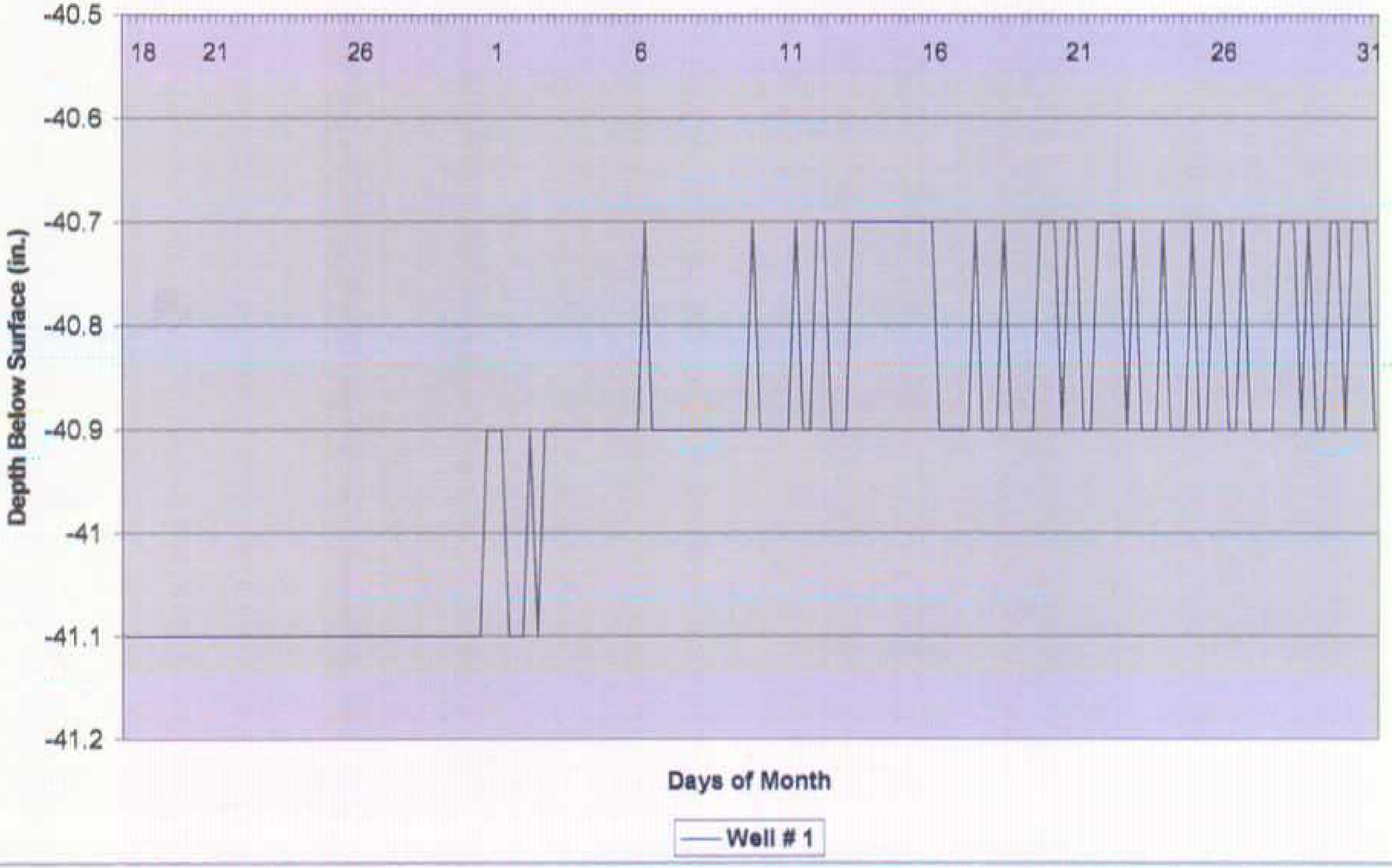


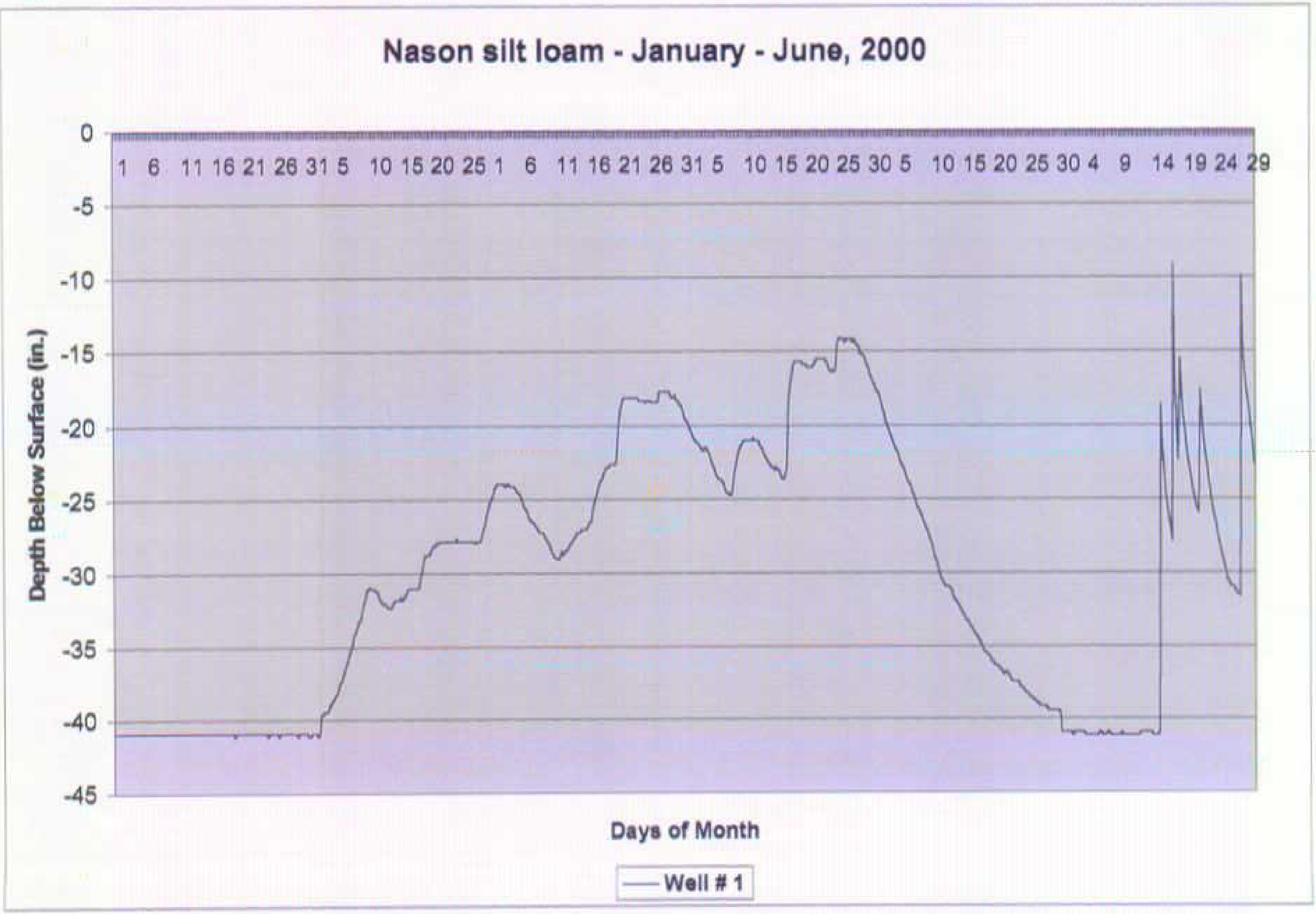
 500 ft Scale: 1 : 12,800 Detail: 14-0 Datum: WGS84



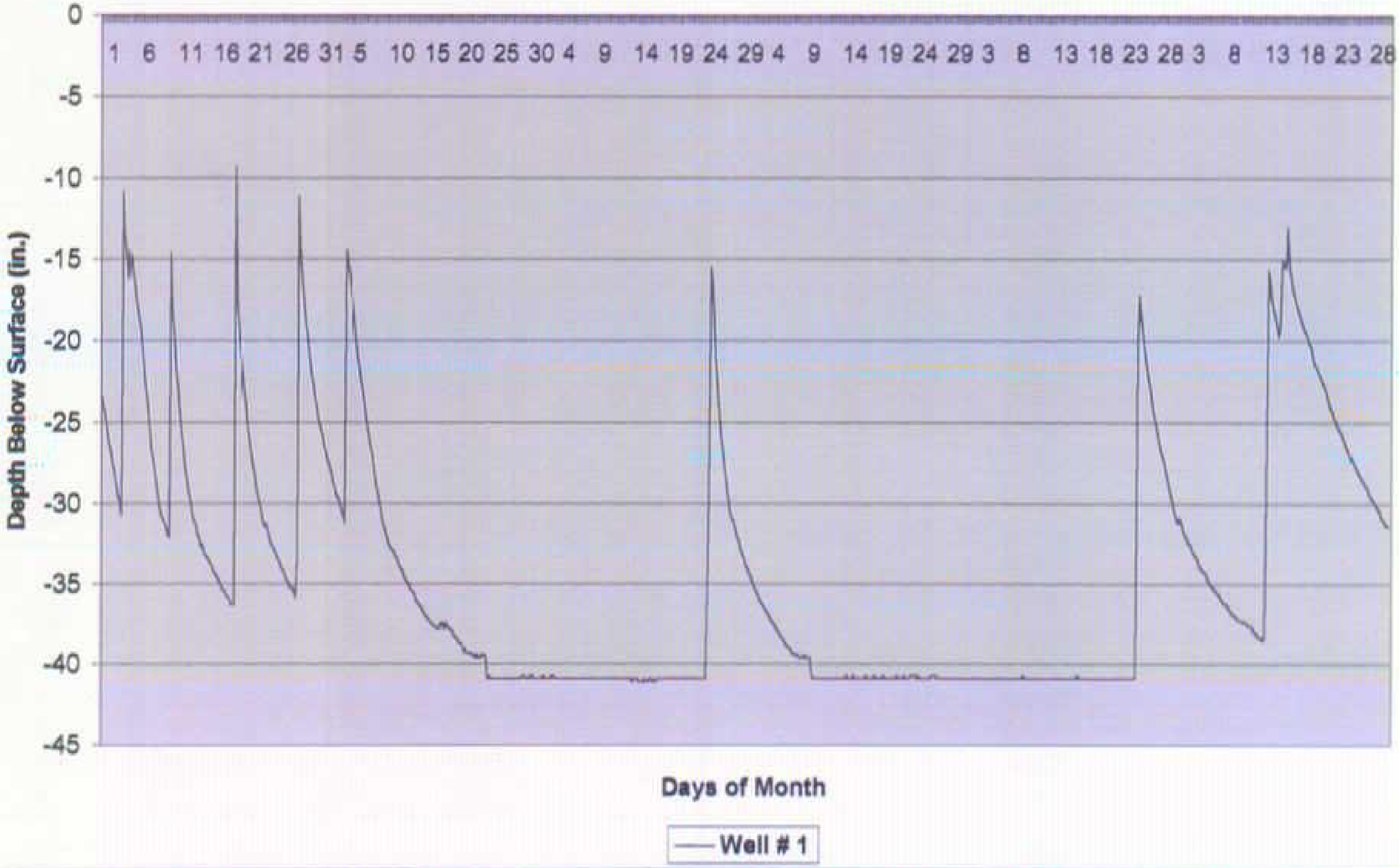
Spotsylvania County Precipitation Comparison
Precipitation (in.)
12
10
8
6
4
2
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
29 Year Average
1999
2000
2001

Nason silt loam - November - December, 1999

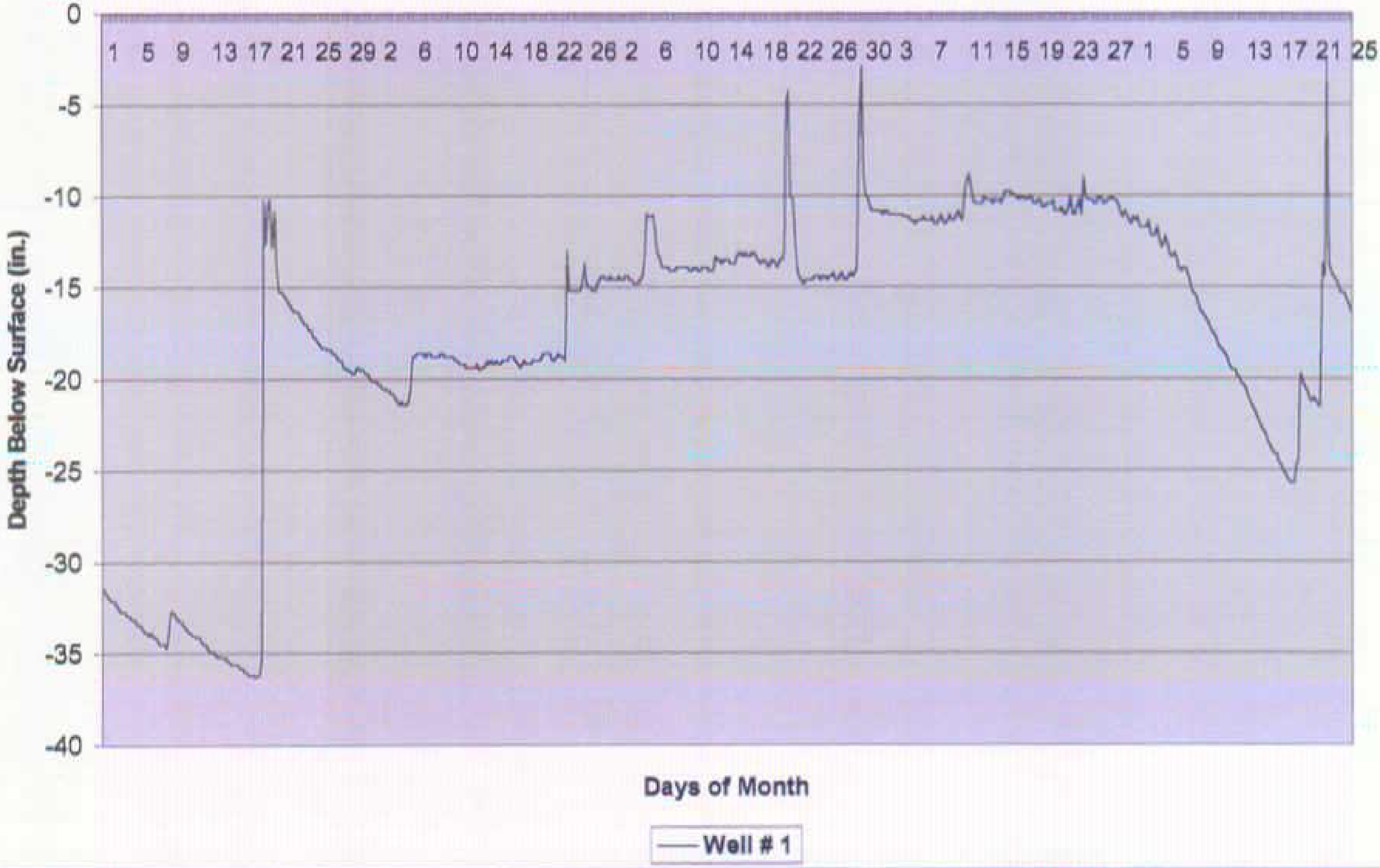



Nason silt loam - January - June, 2000
Depth Below Surface (in.)
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
1 6 11 16 21 26 31 5 10 15 20 25 1 6 11 16 21 26 31 5 10 15 20 25 30 5 10 15 20 25 30 4 9 14 19 24 29
Days of Month
Well # 1

Nason silt loam - July - December, 2000



Nason silt loam - January - May, 2001



SOIL EVALUATED: Nimmo fine sandy loam

LOCATION:

This research site was located in the southern portion of the City of Virginia Beach, Virginia. Refer to the accompanying portion of the Pleasant Ridge U.S. Geologic Survey topographic map for the general character of the area. The accompanying detailed site sketch shows the location of two automated WL-40 data loggers on this residential property.

RATIONALE FOR SITE SELECTION:

There were several reasons for using this site. First, the type of soil at the site, Nimmo, represents a major soil type located over large areas in the Cities of Chesapeake and Virginia Beach. To study it would provide valuable information that could apply to numerous sites considered for onsite septic systems. Second, while the Nimmo soil meets Virginia criteria to allow installation of a conventional gravity drainfield in the Cities of Chesapeake and Virginia Beach, drainfields in this soil often do not work properly on a year-round basis. And finally, since hydric soils are not used in other parts of the state due to wetland issues, this study could provide information on how well this subsurface septic system works in problem soils.

SOIL_ AN DS ITE_IN EORMAT. ION

The soil at this site formed in moderately coarse textured, stratified, unconsolidated, fiuvio-marine sediments of the lower Coastal Plain. The site was on a broad, level to nearly level fiat. The wells were located in a yard, vegetated with fescue-type lawn grasses. Well # I was located in the area of the subsurface conventional drainfield and Well # 2 was located between the drainfield and the surrounding ditches.

The published Soil Survey of City of Vir,qinia Beach, Vir.qinia, Danny R. Hatch, et. al., September 1985, shows the research site as being mapped as Nimmo loam (24). Nimmo is a poorly drained soil. The research site has surface textures of fine sandy loam vs. the loam listed in the mapping unit name.

A detailed soil profile description was made at the site and is included. When comPared to the official soil series description for the Nimmo series (refer to the Appendix), the soil at this site falls within the range of characteristics. That means the soil was typical or representative of Nimmo soils.

Since the soil was suitable for a conventional gravity drainfield only by 'current regulations (hydric soil), the subsurface conventional system had septic trenches 18 inches below the surface. These trenches were 3 feet wide and 100 feet long. The drainfield must be surrounded with ditches with inverts at least 6 inches deeper than the invert of the septic trenches. The ditches must be 70 feet plus or minus 10 from the existing drainfield and/or reserve area. The finished drainfield area is to be capped and crowned to encourage surface removal of water from the site.

CLIMATIC DATA FOR THE SITE:

Precipitation was monitored at the site by the homeowner. This current data was compared to the precipitation data published in the Soil Survey of City of Vir,qinia Beach, Vir.qinia referenced above. This precipitation data from the home site was used to evaluate rainfall during the study period. The precipitation comparison graph shows how each month's rainfall total compares to the monthly 29-year average (1949-1978).

It is apparent that 1999 was a very abnormal year. Hurricanes Dennis, Floyd and Irene produced rainfall totals in excess of 33 inches during a six week period from September 3 through October 18. For the March-June period, precipitation was slightly above normal with 1.96 inches above or 115%. For the July-December period, precipitation was dramatically above normal. In fact, rainfall was 189% of the long-term average for that period. Therefore, the water table levels at the site would be expected to be shallower (nearer to the surface) than during a year with normal precipitation.

For.the_period January~June.2000,_.total._precipitation was_ _1.4.7 inches above the 29-year average or 173%. That .means that the water table levels would be expected to be much above normal at the site.

For the period July-December 2000, monthly rainfall was above normal. Precipitation was 3.35 inches above the 29-year average or 114%. That means that the water table levels would be expected to be above normal at the site.

Fifteen of the twenty two months (March, April, May, June, July, August, September and October 1999, January, April, May, June, July, August and September 2000) had precipitation levels above normal. For the entire study period of March 1999 through December 2000, overall precipitation was 41.71 inches above the 29-year average or 151%. Water table levels would be expected to be above normal at the site.

RESULTS:

Two automated data loggers .were installed at the site on February 19,1999. Wells were installed in the same soil, same landscape position and at the same topographic elevation. Well # 1 was installed within the footprint of an operating conventional subsurface drainfield wastewater system and Well # 2 was installed 100 feet away. Well # 2 was representative of the soil conditions at the conventional subsurface drainfield system site but was remote enough to be unaffected by the wastewater system. Due to operator error, Wells # 1 and # 2 were not programmed properly and the collection of water table data did not commence until March 13,1999. There was continuous data collection from the starting date until December, 2000.

The Nimmo soil at this site had a gleyed matrix of light brownish gray (10YR 6/2) with common yellowish red (5YR 5/6) and olive yellow (2.5Y 6/6) mottles from 8-12 inches to 30 inches. This Btgl horizon has loam textures. The Btg2 horizon is sandy loam from 30 to 36 inches and light brownish gray (10YR 6/2) with many strong brown (7.5YR 5/6) and olive yellow (2.5¥ 6/6) mottles. The Cg horizon is sand from 36 to 48 inches and light gray (10YR 7/1) with many brownish yellow (10¥R 6/6) mottles. This soil has uniform Permeability throughout. Nimmo is a poorly drained soil. This soil normally has an apparent water table, which comes up from the bottom during precipitation events and goes down during dry periods.

The water table hydrograph of March - June, 1999 shows the presence of free water in the soil within 12 inches for 0 days, 12-18 inches for 0-1 days, 18-24 inches for 0-3 days, 24-30 inches for 3-8 days, 30-36 inches for 8-34 days, 36-40 inches for 26-50 days and dry for 59-83 days. Rainfall for this period was above average or 15.4 inches. March, April, May and June were all above normal in precipitation.

The March - June, 1999 Groundwater Data Table shows that the surface of the free water for Well # 1 was below the Ap horizons for the entire time during this 109 day period, in the Btgl horizon 0-3 days or 0-2% of the time and the Btg2 horizon 8 days or 7% of the time. The Cg horizon had free water 26 days or 24% of the time from 36 to 40 inches and was dry below 40 inches for 83 days or 74% of the time. For Well # 2, the surface of the free water was below the Ap horizon for the entire time during this 109 day period, in the Btgl horizon 1-8 days or 1-6% of the time and the Btg2 horizon 34 days or 31% of the time. The Cg horizon had free water 50 days or 45% of the time from 36 to 40 inches and was dry below 40 inches for 59 days or 53% of the time.

The water table hydrograph of July - December, 1999 shows the presence of free water in the soil within 12 inches for 1-3 days, 12-18 inches for 3-4 days, 18-24 inches for 5-7 days, 24-30 inches for 9-13 days, 30-36 inches for 19-25 days, 36-40 inches for 29-31 days and dry for 154-155 days. Rainfall for this period was dramatically above average or 46.2 inches. Precipitation during this six week period of the hurricanes was in excess of 33 inches. July, August, September and October were above normal while November and December were below normal in precipitation.

The July - December, 1999 Groundwater Data Table shows that the surface of the free water for Well # I was in the Ap horizon 1-2 days or 1% of the time during this 184 day period, in the Btgl horizon 3-9 days or 2-5% of the time and the Btg2 horizons 19 days or 10% of the time. The Cg horizon had free water 29 days or 16% of the time from 36 to 40 inches and was dry below 40 inches for 155 days or 85% of the time. For Well # 2, the surface of the free water was in the Ap hodzon 2-3 days or 1-2% of the time, in the Btgl horizon 4-13 days or 2-7% of the time and the Btg2 hodzon 25 days or 14% of the time. The Cg horizon had free water 31 days or 17% of the time from 36 to 40. inches and was dry below 40 inches for 154 days or 83% of the time.

The water table hydrograph of January - June, 2000 shows the presence of free water in the soil within 12 inches for 0-3 days, 12-18 inches for-3-6 days, 18-24 inches for 7-12 days, 24-30 inches for 14-34 days, 30-36 inches for 39-90 days, 36-40 inches for 89-120 days and dry for 62-93 days. Rainfall for this period was dramatically above average or 34.8 inches. January, April, May and June were above normal while February and March were below normal in precipitation.

The January - June, 2000 Groundwater Data Table shows that the surface of the free water for Well # 1 was in the Ap horizon 0-1 days or 1% of the time during this 182 day period, in the Btgl horizon 3-14 days or 2-7% of the time and the Btg2 horizons 39 days or 21% of the time. The Cg horizon had free water 89 days or 49% of the time from 36 to 40 inches and was dry below 40 inches for 93 days or 52% of the time. For Well # 2, the surface of the free water was in the Ap horizon 2-3 days or 1-2% of the time, in the Btgl horizon 6-34 days or 3-18% of the time and the Btg2 horizon 90 days or 49% of the time. The Cg horizon had free water 120 days or 66% of the time from 36 to 40 inches and was dry below 40 inches for 62 days or 34% of the time.

The water table hydrograph of July - December, 2000 shows the presence of free water in the soil within 12 inches for 0-2 days, 12-18 inches for 2-6 days, 18-24 inches for 8-18 days, 24-30 inches for 24-41 days, 30-36 inches for 46-65 days, 36-40 inches for 78-87 days and dry for 97-106 days. Rainfall for this period was slightly above average or 27.85 inches. July, August and September were above' normal while October, November and December were below normal in precipitation. October had no precipitation.

The July - December, 2000 Groundwater Data Table shows that the surface of the free water for Well # 1 was below the Ap horizon for the entire time during this 184 day period, in the Btgl horizon 2-24 days or 1-13% of the time and the Btg2 horizon 46 days or 25% of the time. The Cg horizon had free water 78 days or 43% of the time from 36 to 40 inches and was dry below 40 inches for 106 days or 52% of the time. For Well # 2, the surface of the free water was in the Ap horizon 0-2 days or 1% of the time, in the Btgl horizon 6-41 days or 3-22% of the time and the Btg2 horizon 65 days or 35% of the time. The Cg horizon had free water 87 days or 47% of the time from 36 to 40 inches and was dry below 40 inches for 97 days or 53% of the time.

CONCLUSIONS:

This site had precipitation levels above normal for 15 months of the 22 months the study was conducted. Those fifteen months, March, April, May, June, July, August, September and October, 1999; and January, April, May, June, July, August and September, 2000; had totals of 113.95 inches, 53.66 inches above normal. That relates to 189% of normal precipitation for those 15 months. The total study period (22 months) had 124.25 inches. Based on the 29-year average, this retates to 151% of norma~ precipitation.

Even with above normal precipitation, free water was not present for significant periods of time during the study period. The water tables did come up during heavy rain events but did not stay up for long periods.

Free water was observed in the Ap horizon for short periods of time and was always associated with precipitous rises in the water table. For the entire study period, free water was in this horizon for 0 to 8 days of the total 659 days or 0 to less than I percent, of the time, though not continuously. There were no soil morphological features that could be related to the presence of water in the soil for the number of days observed except for thickness.

Free water was observed in the Btgl horizon for 8 to 96 days of the total 659 days during the entire study period, and was always associated with sharp rises in the water table. This relates to I to 15 percent of the time. Strong brown (7.5YR 5/6) and olive yellow (2.5Y 6/6) mottles in a gleyed matrix were soil morphological features that could be related to the presence of water in the soil for extended periods of time.

Free water was observed in the Btg2 horizon for 112 to 214 days of the total 659 days during the entire study period and was always associated with sharp rises in the water table. This relates to 17 to 32 percent of the time. Strong brown (7.5YR 5/6) and olive yellow (2.5Y 6/6) mottles in a gleyed matrix were soil morphological features that could be related to the presence of water in the soil for extended periods of time.

Free water was observed in the Cg hodzon for 182 to 288 days of the total 659 days dudng the entire study period and was always associated with sharp rises in the water table. This relates to 28 to 44 percent of the time. Brownish yellow (10YR 6/6) mottles in a gleyed matrix were soil morphological features that could be related to the presence of water in the soil for extended periods of time.

The presence of strong brown (7.5YR 5/6) and olive yellow (2.5Y 6/6) mottles in a gleyed matrix were redoximorphic features (mottles) that could be related to the presence of water in the soil for some periods of time. During the winter-spring time of the year, the seasonal water table was present in the Btgl horizon for 1/16 to 1/7 of the time.

It must be remembered that when the surface of the water table was in one of the upper horizons such as the Btgl horizon, the Btg2 horizon and lower horizons were saturated for longer periods. Free water was observed in the Btg2 hodzon for 1/7 to 1/3 of the winter-spring time. This hodzon had strong brown (7.5YR 5/6) and olive yellow (2.5Y 6/6) redoximorphic features (mottles).

The presence of brownish yellow (10YR 6/6) mottles in a gleyed matrix were redoximorphic features (mottles) that could be related to the presence of water in the soil for some periods of time.' During the winter-spring time of the year, the seasonal water table was present in the Cg horizon for 4/10 to 6/10 of the time.

As was noted earlier, this soil met the minimum state requirements for a conventional gravity drainfield based on regulations in contrast to soil morphology. Based on the period studied, it is apparent that the gravel filled trenches (at a depth of 18 inches) for the existing conventional septic system would have been inundated with free water for very short periods of time. Free water was present in the trench area for 0 to 7 days or 0% to 2% of the time during the winter-spring period. Based on the state sewage regulations in effect when the permit was issued, an 12 inch zone of suitable soil beneath the gravel filled trenches would have been required (the "stand-off zone") for treatment and disposal of the wastewater. Based on this research, the seasonal water table .would have been in the "stand-off zone" at least 17 to 42 days or 6% to 14% of the time during a winter-spring period. Although soil morphology indicated this soil was unsuitable for a conventional gravity drainfield, the monitoring data taken while there was above normal precipitation showed the soil was suitable.

It should be pointed out that the drainfleld stayed reasonably dry for a majority of the time. This might be due to the rapid permeability of the soil in reference to wastewater input. This soil responded well to drainage of the soil by the off site ditches.

Nimmo fine sandy loam

Profile for Well # 1' (WL40)

Ap--0 to 12 inches, dark grayish brown (10YR 4/2) fine sandy loam; weak coarse granular structurel very friable, nonsticky, nonplastic.

Btgl-12 to 30 inches, light brownish gray (10YR 6/2) loam; common medium distinct strong brown (7.5¥R 5/6) and olive yellow (2.5Y 6/6) mottles; weak medium subangular blocky structure; friable, slightly sticky, slightly plastic.

Btg2--30 to 36 inches, light brownish gray (10YR 6/2) sandy loam; many coarse distinct strong brown (7.5YR 5/6) and olive yellow (2.5Y 6/6) mottles; weak coarse subangular blocky structure; friable, slightly sticky, nonplastic.

Cg--36 to 48 inches, light gray (10YR 7/1) sand; many medium and coarse distinct brownish yellow (10YR 6/6) mottles; massive; single grain structure; loose.

Remarks: This profile taken from an auger hole.

Profile for Well # 2: (WL40)

Ap--0 to 8 inches, dark grayish brown (10YR 4/2) fine sandy loam; weak coarse granular structure; very friable, nonsticky, nonplastic.

Btgl-8 to 30 inches, light brownish gray (10YR 6/2) loam; common medium distinct strong brown (7.5YR 5/6) and olive yellow (2.5Y 6/6) mottles; weak medium subangular blocky structure; friable, slightly sticky, slightly plastic.

Btg2--30 to 36 inches, light brownish gray (10YR 6/2) sandy loam; many coarse distinct strong brown (7.5YR 5/6) and olive yellow (2.5Y 6/6) mottles; weak coarse subangular blocky structure; friable, slightly sticky, nonplastic.

Cg--36 to 48 inches, light gray (10YR 7/1) sand; many medium and coarse distinct brownish yellow (10YR 6/6) mottles; massive; single grain structure; loose.

Remarks: This profile taken from an auger hole.

Table .1 - - Nimmo fine sandy loam Groundwater Data Table
March-June, 1999 (109 Days)

	Well # 1				Well # 2			
				Percent				Percent
Depth Range (in.)	Number of Days	Percent Time	Cumulative Days	Cumulative Days	Number of Days	Percent Time	Cumulative Days	Cumulative! Days _
0-6	0	0	0	0	0	0	0	0 _
6.1-12	0	0	0	0	0	0	0	0
12.1-18	0	0	0	0	1	1	1	1
18.1-24	0	0	0	0	2	I	3	2
24.1-30	3	3	3	2	5	5	8	6
30.1-36	5	5	8	7	26	25	34	31
36.1-40	18	18	26	24	16	15	50	45
Dry	83	74	109	100	59	53	109	100

Table 2 - - Nimmo fine sandy loam Groundwater Data Table
July-December, 1999 (184Days)

	Well # 1				Well # 2			
				Percent				Percent
Depth Range (in.)	Number of Days	Percent Time	Cumulative Days	Cumulative Days	Number of Days	Percent Time	Cumulative Days	Cumulative Days
0-6	1	0	I	0	2	1	2	1
6.1-12	1	0	2	1	1	1	3	2
12.1-18	I	1	3	2	1	1	4	2
18.1-24	2	I	5	3	'3	1	7	4
24.1-30	4	2	9	5	5	3	13	7
'30.1-36	10	5	19	10	12	7	25	14
36.1-40	10	6	29	16	6	3	31	17
Dry	155	85	184	100	154	83	184	100

Number of Days column refers to the number of days the surface of the free water was present within the depth range.

Percentage of Time column refers to the percent of time the water was present within the depth range.

Cumulative Days column refers to the total number of days the water was present within the depth range.

Percentage of Cumulative Days refers to the percent of total time the water was present within the depth range.

DRY corresponds to the number of readings (converted to days) where the monitoring well recorded no water in the hole.

Days in the column headings corresponds to the number of data logger readings within a depth range divided by the number (normally 2, 4 or 8) of data logger readings per day.

Table 3 - - Nimmo fine sandy loam Groundwater Data Table
January-June, 2000 (182 Days)

	Well # 1				Well # 2			
				Percent				Percent
Depth Range (in.)	Number of Days	Percent Time	Cumulative Days	Cumulative Days	Number of Days	Percent Time	Cumulative Days	Cumulative Days _
0-6	0	0	0	0	2	1	2	I _
6.1-12	1	0	1	1	1	1	3	2 _
12.1-18	2	1	3	2	3	2	6	3 _
18.1-24	4	2	7	4	6	3	12	6
24.1-30	7	4	14	7	22	12	3,4	18 _
30.1-36	25	14	39	21	56	31	90	49 _
36.1-40	50	27	89	49	30	16	120	66
Dry	93	52	182	100	62	34	182	100

Table 4 - - Nimmo fine sandy loam Groundwater Data Table
July-December, 2000 (184Days)

	Well # 1				Well #2			
				Percent				Percent
Depth Range (in.)	Number of Days	Percent Time	Cumulative Days	Cumulative Days	Number of Days	Percent Time	Cumulative Days	Cumulative Days
0-6	0	0	0	0	0	0	0	0
6.1-12	0	0	0	0	2	1	2	1
12.1-18	2	1	2	I	4	2	6	3
18.1-24	6	3	8	5	12	7	18	10
24.1-30	16	9	24	13	23	12	41	22
30.1-36	22	12	46	25	24	13	65	35
36.1-40	32	23	78	43	22	12	87	47
Dry	106	52	184	100	97	53	184	100

Number of Days column refers to the number of days the surface of the free water was present within the depth range.

Percentage of Time column refers to the percent of time the water was present within the

depth range.

Cumulative Days column refers to the total number of days the water was present within the depth range.

Percentage of Cumulative Days refers to the percent of total time the water was present within the depth range.

DRY corresponds to the number of readings (converted to days) where the monitoring well recorded no water in the hole.

Days in the column headings corresponds to the number of data logger readings within a depth range divided by the number (normally 2, 4 or 8) of data logger readings per day.

City of Virginia Beach
Nimmo Fine Sandy Loam
Scale: 1"= 50'

Property_line & open_ditch

240'

O
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Data Logger #2
WL-40

O
._c~

99'

D ta L er#1

Q.
,c~O

~-
n

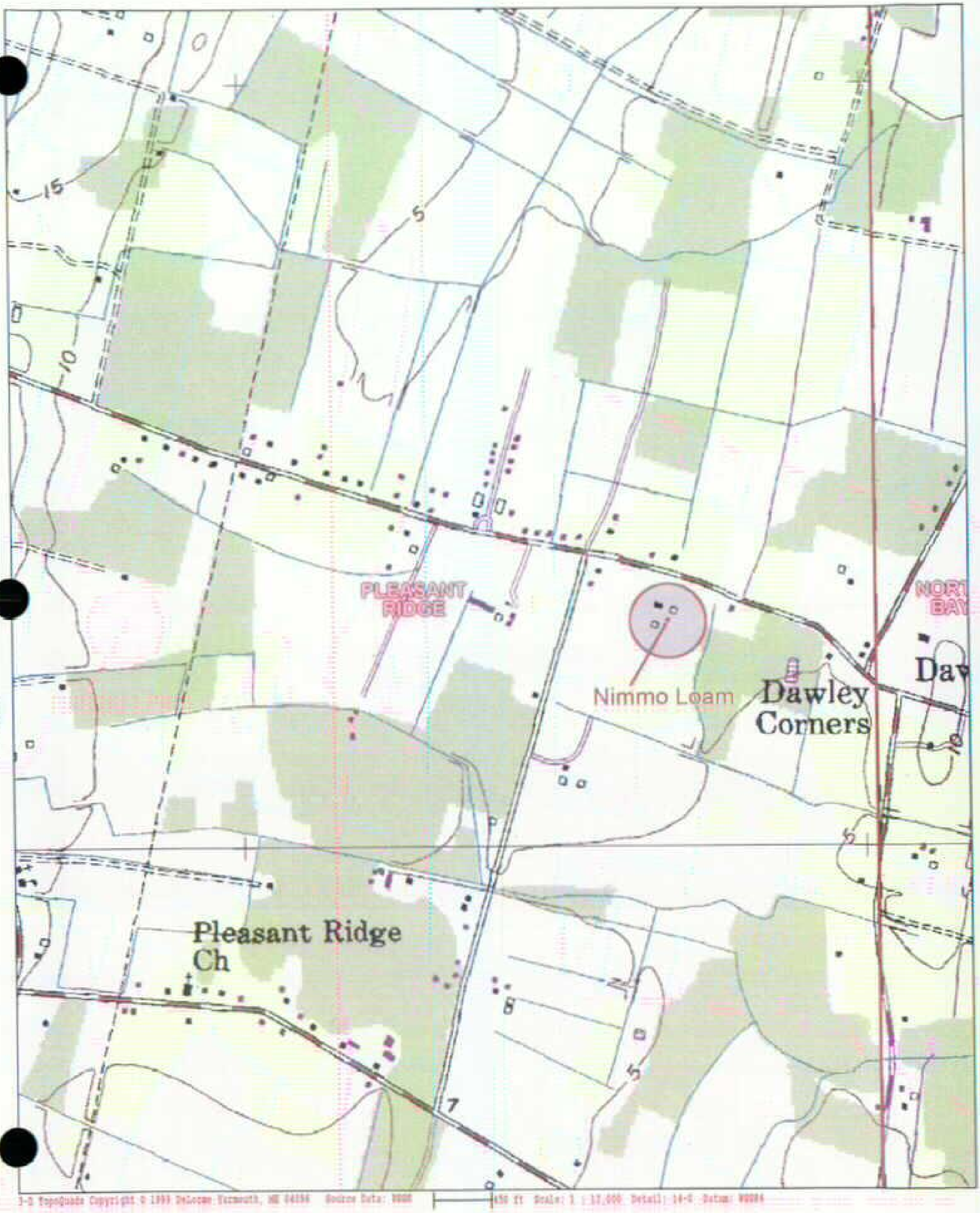
Subsurface ,
Drainfield

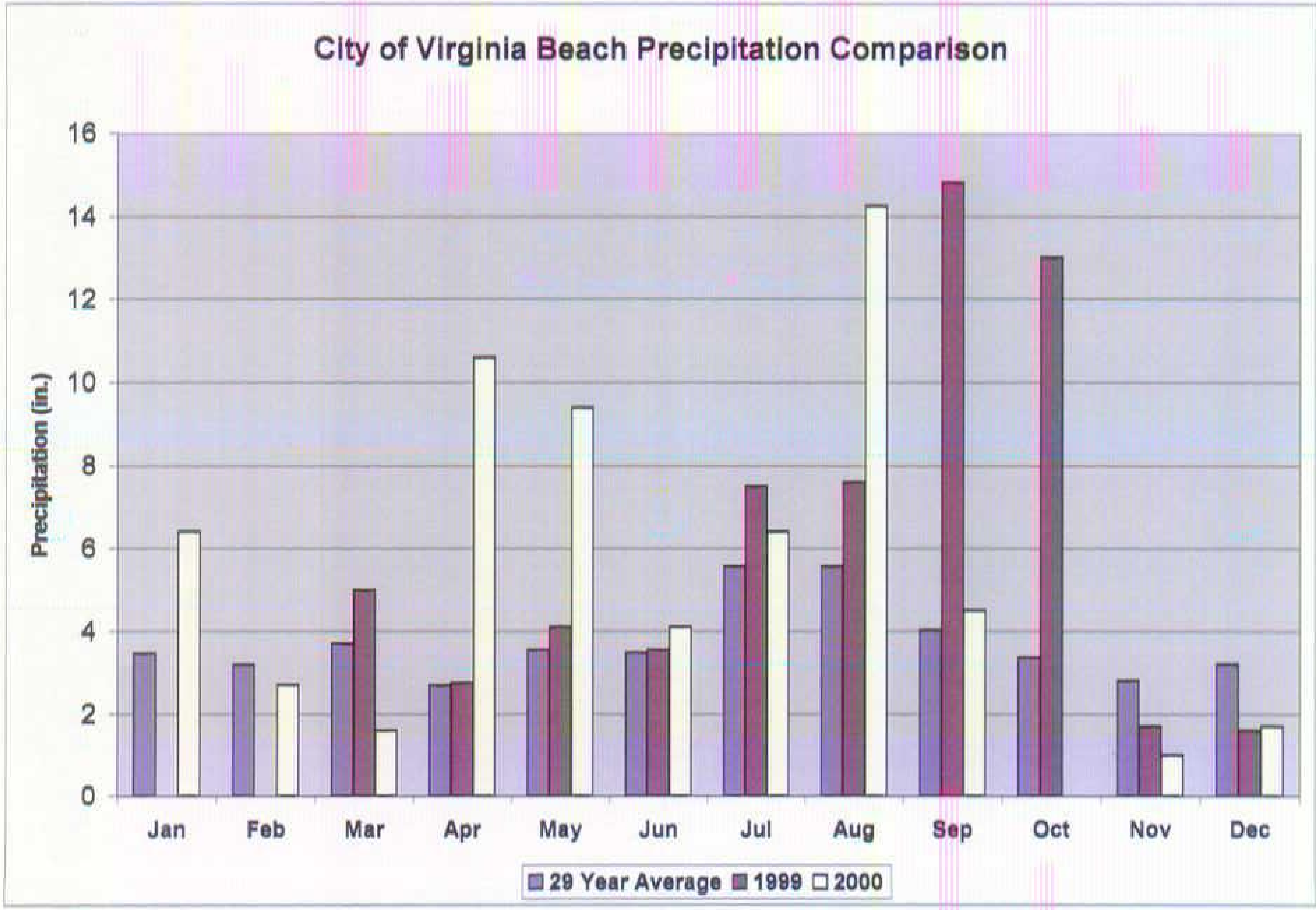
French Drain

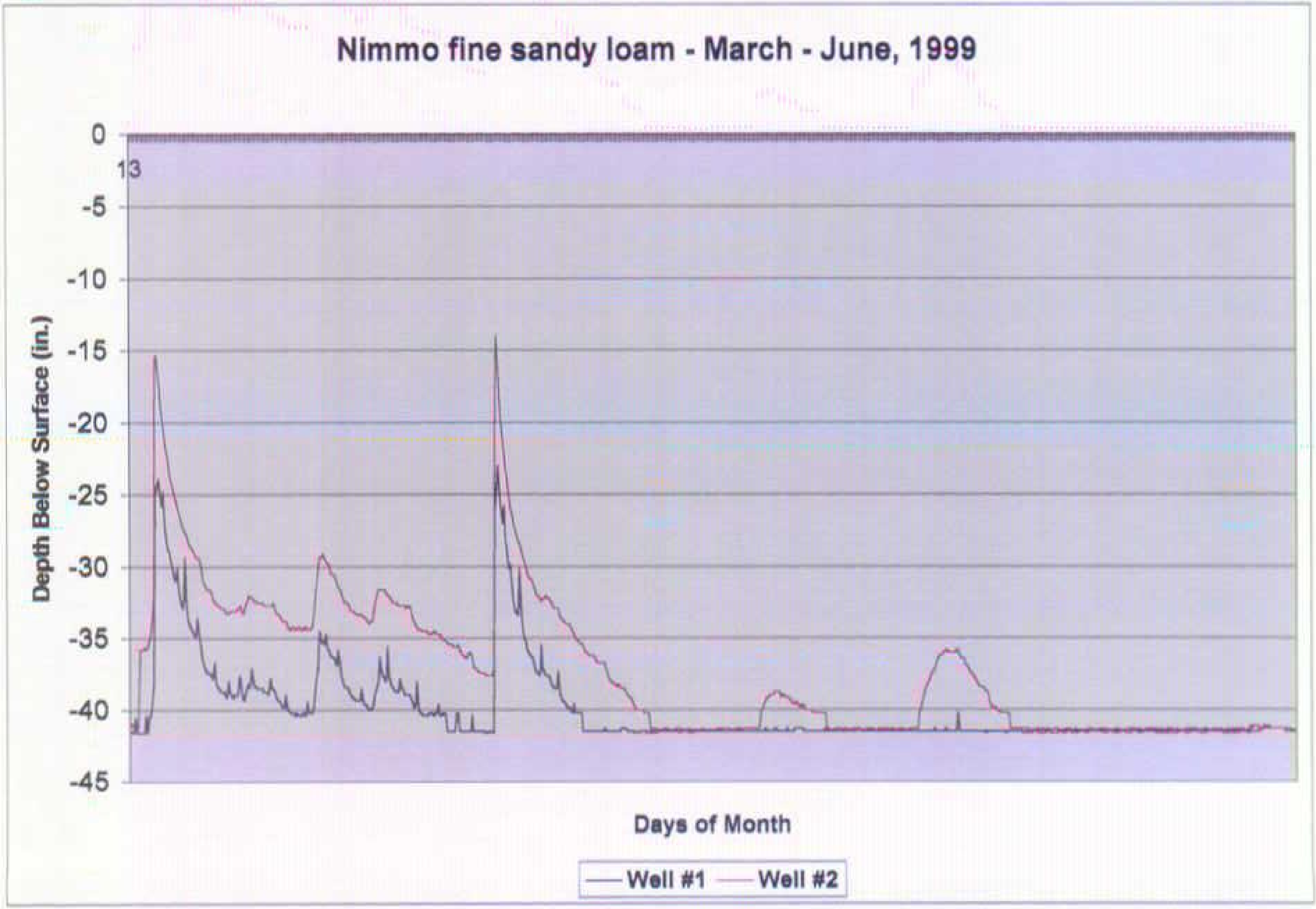
Shed]

Pool & Deck Area

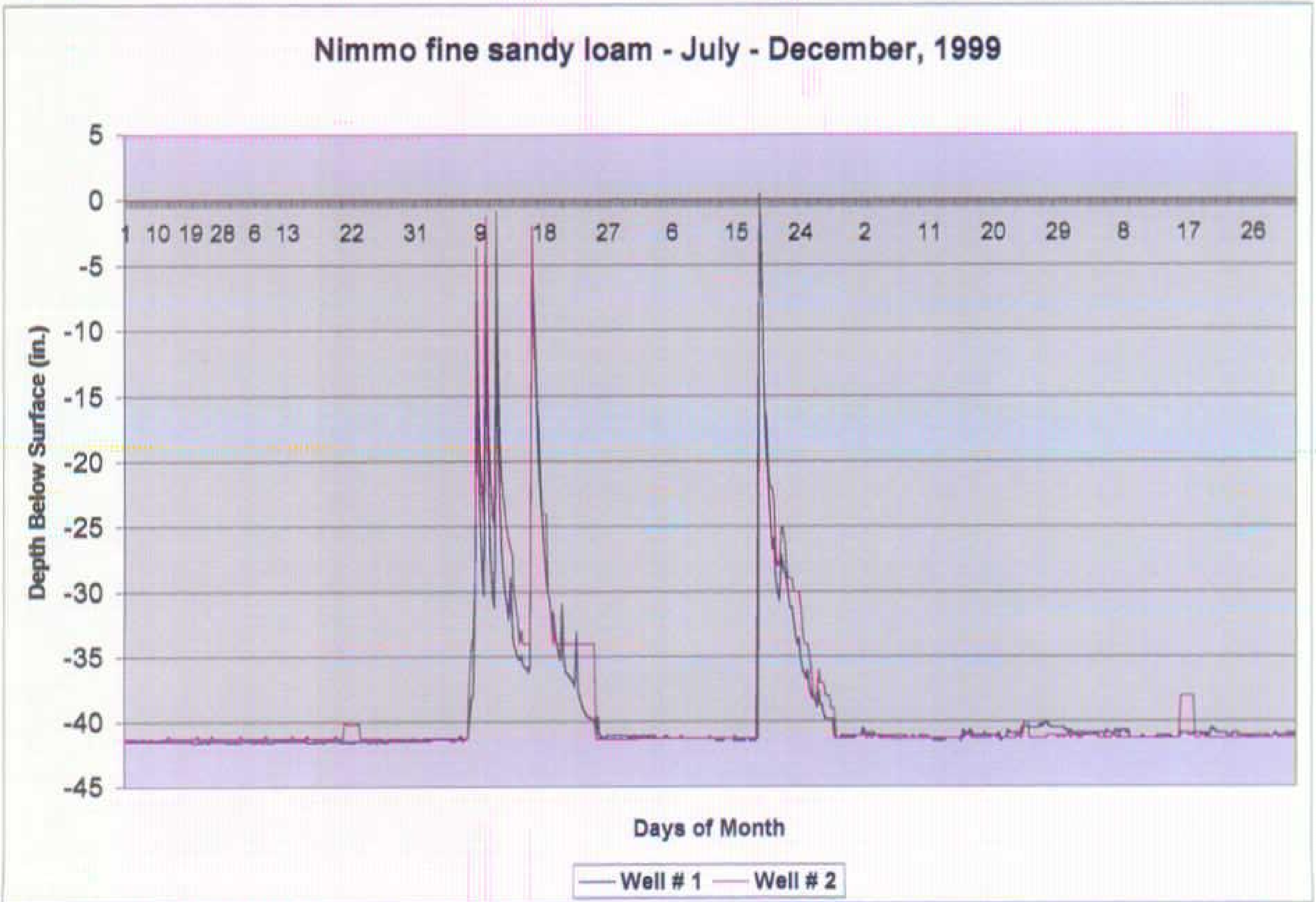
House

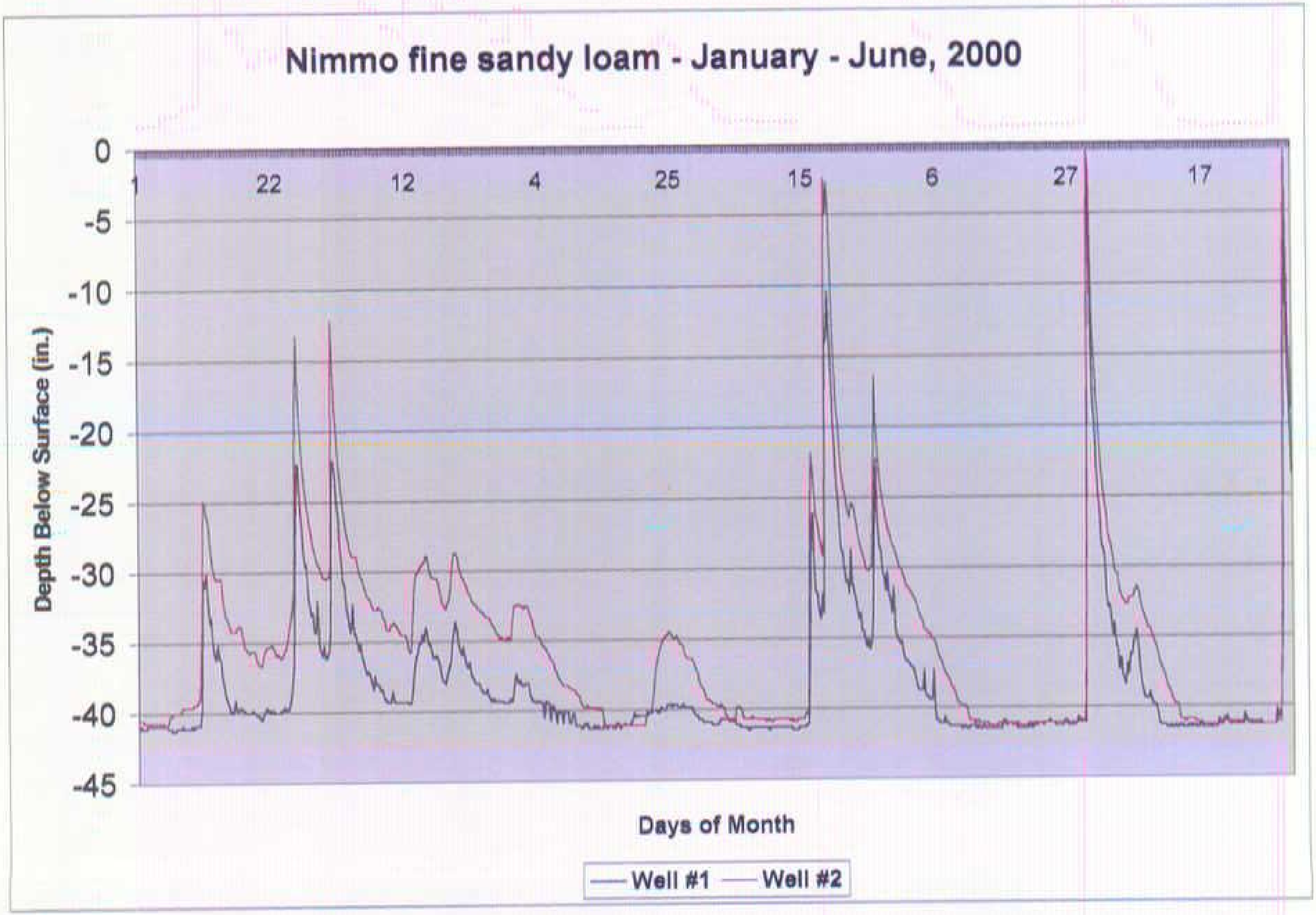

15
5
10
PLEASANT RIDGE
NORT BAY
Nimmo Loam
Dawley Corners
Dav
Pleasant Ridge Ch
5
7
10


City of Virginia Beach Precipitation Comparison
Precipitation (in.)
16
14
12
10
8
6
4
2
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
29 Year Average
1999
2000

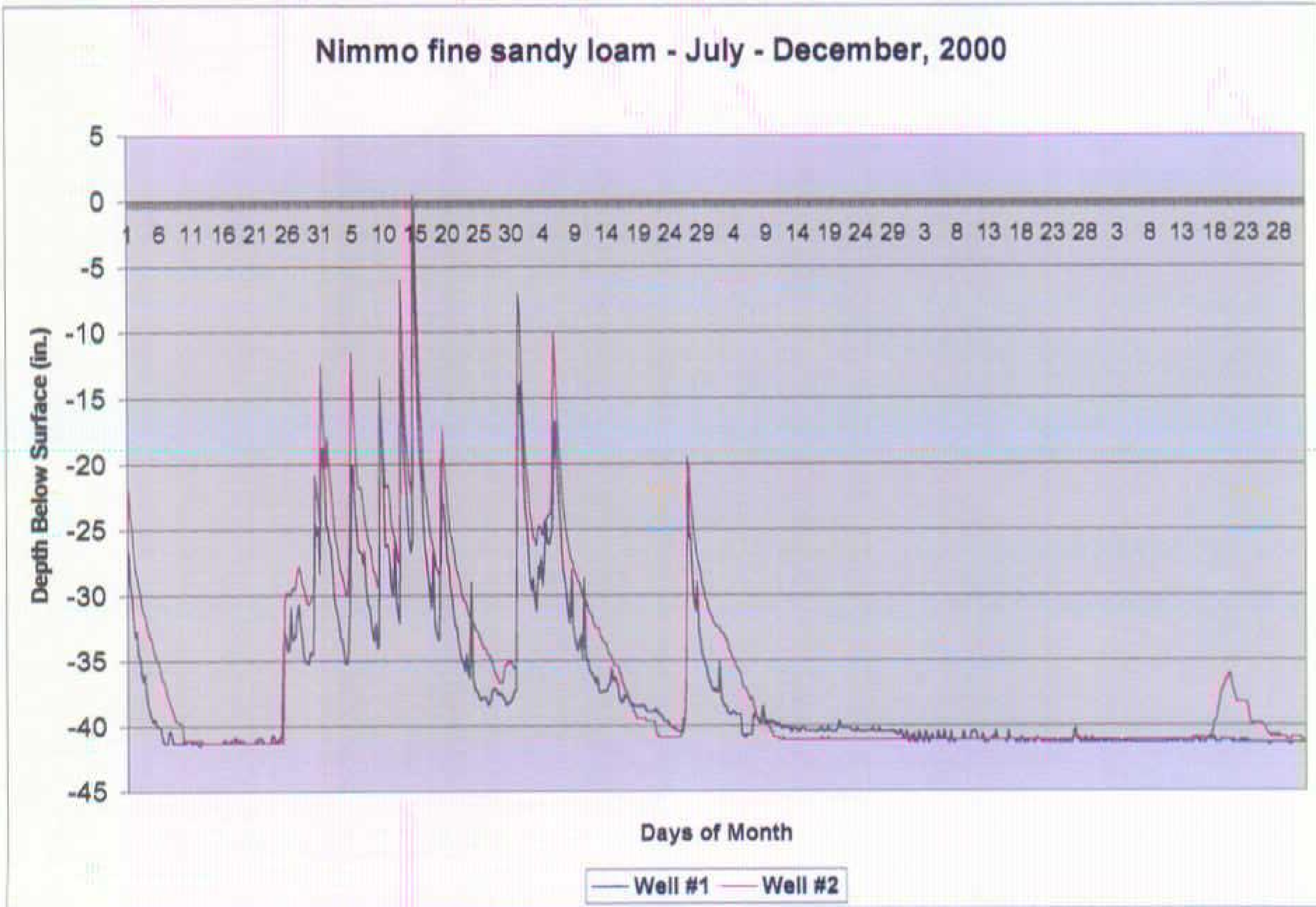


Nimmo fine sandy loam - March - June, 1999
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
Depth Below Surface (in.)
13
Days of Month
Well #1
Well #2


Nimmo fine sandy loam - July - December, 1999
Depth Below Surface (in.)
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
1 10 19 28 6 13 22 31 9 18 27 6 15 24 2 11 20 29 8 17 26
Days of Month
Well # 1
Well # 2



Nimmo fine sandy loam - January - June, 2000
Depth Below Surface (in.)
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
1
22
12
4
25
15
6
27
17
Days of Month
Well #1
Well #2


Nimmo fine sandy loam - July - December, 2000
Depth Below Surface (in.)
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
1 6 11 16 21 26 31 5 10 15 20 25 30 4 9 14 19 24 29 4 9 14 19 24 29 3 8 13 18 23 28 3 8 13 18 23 28
Days of Month
Well #1
Well #2

SOIL EVALUATED: PENN LOAM

LOCATION:

The study site is in the Piedmont province in the western part of Fair[ax County, Virginia. The county boundary between Fair[ax and Loudoun runs through part of the overall study site. Refer to the accompanying portion of the U.S. Geological Survey topographic map for the general topography and landforms. The accompanying site sketch shows the location of one data logger in the Penn soil, and two data loggers in the Kelly soil. (The Kelly well sites are discussed in the main part of the Kelly narrative. The Kelly and Penn soils will also be discussed together in this Penn narrative.)

RATIONALE FOR SITE SELECTION:

The study site is in the Triassic basin and has diverse geologic and soil dynamics occurring in a small area. The study site represents Triassic geology and soil that is present over many thousands of acres in Fair[ax, Prince William, Loudoun, Fauquier, and Culpeper Counties in Northern Virginia. Also, there are several thousand drainfields in the Penn and related soils throughout Northern Virginia. The monitoring well is located close to a large mass drainfield that appears to be functioning well.~ Information from the Watertable study will give a reasonable idea of what groundwater levels are present in and around the mass drainfield. Finally, the Penn soil has reddish subsoil colors that are mainly inherited from the Triassic redbed parent materials. These reddish colors may be masking any watertable features at this particular site.

SOIL AND SITE INFORMATION:

The Penn soil at the study site has developed in mostly residual soil materials weathered from Triassic sedimentary redbeds that consist of reddish shale, siltstone, and fine-grained sandstone. The Penn monitoring well site is in the edge of a wooded area that has cedars and hardwood understory. The site is also near the edge of a large mass drainfield that serves a public gold course. Based on the flatness of the topography, it does not appear the drainfield had much influence on the watertable in the Penn soil.

The Soil Survey of Fair[ax County, Virginia (H.C. Porter et al., 1963) and the Soil Survey of Loudoun County, Virginia (H.C. Porter et al., 1960) has the study area mapped (Sheet 14 in Fair[ax Soil Survey and Sheet 48 in Loudoun Soil Survey) as Pm: Penn silt loam, eroded 'undulating phase and Ka-Kb: Kelly silt loam, undulating phase. A detailed soil profile was made at the Penn site using a backhoe pit. When compared to the official soil series for the Penn soil (refer to the Appendix) the Penn soil at the study site generally falls within the range of characteristics. Additionally, the Penn soil in this study is similar to the Penn soil concepts mapped in the old Fair[ax and Loudoun County Soil Surveys cited above.

CLIMATIC DATA FOR THE STUDY SITE:

The Penn soil study site is about 12 miles east of The Plains, a NOAA weather data station. Weather data from The Plains (1999, 2000, 2001, and 29-year average) was used to provide yearly and monthly precipitation figures for the study site. The precipitation comparison graph for Fairfax and Prince William Counties shows how each monthly precipitation total compares to the monthly 29-year averages (1961-1990).

During the November-December 1999 study period, precipitation was below normal. Rainfall for the two months totaled 3.79 inches, which is 2.61 inches less than the 29-year average total of 6.40 inches. In addition, much of Virginia was having drought conditions during 1999 and 2000.

During the January-June 2000 study period, total precipitation was 21.79 inches, which was 1.54 inches more than the 29-year average of 20.25 inches. June had the most precipitation at 6.55 inches followed by April with 4.72 inches. (June had the highest total for any month during the study period from November 1999 to May 2001.) February had the lowest precipitation total of 1..98 inches.

During the July-December 2000 study period, total precipitation was 20.33 inches, which is 1.55 inches less than the 29-year average of 21.88 inches. August had the highest total precipitation at 6.24 inches, and October had the lowest total at 0.16 inches. (October 2000 was also the driest month in many other parts of eastern and _. central Virginia. Only 0.05 inches were recorded in the Fredericksburg area during the study period.) The anomalous dry October only serves to emphasize how well annual precipitation is distributed in Virginia.

For the final study period form January-May 2001 (Penn watertable monitoring ended May 25), total precipitation was 16.21 inches, nearly the same as the 29-year average of 16.49 inches. March had the highest total at 5.61 inches while February had the lowest total at 1.64 inches.

For the entire study period beginning November 1999 and ending May 2001, total precipitation was about normal as compared to the 29-year average. The major deviations were the relatively dry months near the end of 1999, the relatively wetter than normal months of June and August in 2000, and the much drier than normal month of October 2000. Overall, the Penn soil study site received sufficient precipitation to allow natural watertables to occur.

RESULTS:

An automated data logger (WL-20) was installed at 20 inches below the soil surface in the Penn soil. At the 20-inch depth, the data logger was monitoring the very channery CBt horizon that has 55 to 65% content of shale and siltstone with soil material between the rock materials. The very channery CBt grades into Cr or weathered siltstone/shale bedrock. Continuous automated data collection began on November 18, 1999, and ended on May 25, 2001 (January-May 2001 data is unreliable and excluded).

The overall study site has Penn and Kelly soils. The soils have drastically different features and properties and both occur on the same relatively flat landscape. The soils 'are intimately tied to the geology with the Penn soil derived from Triassic redbeds and the Kelly derived from baked shales, hornfels, and granulites. The Kelly soils (discussed in another part of this report) had perched watertables for a majority of the study period; the Penn soil with its fractured shale-siltstone bedrock did not.

The Penn watertable hydrograph for November-December 1999 shows the monitoring well was dry for the period. At first glance, the hydrograph appears to have significant fluctuations in the watertable; however, the level is around 20 inches and the fluctuation is measured in tenths of an inch. This is considered a dry well. Likewise, the Penn Groundwater Data Table for November-December 1999 shows no watertable present. Total precipitation for November-December 1999 was down from the 29-year average and much of Virginia was having drought conditions. But the Kelly 2 monitoring well site on the same nearly level upland flat as the Penn had a perched watertable in December 1999.

The January-June 2000 watertable hydrograph for Penn shows that there was a brief spike in the watertable to 17 inches below the soil surface in mid April, but the well was dry for most of the period. The Penn GWDT for January-June 2000 indicates the watertable was measured between 12-20 inches below the soil surface for two days in April. Precipitation was 4.72 inches in April compared to the 29-year average of 3.4 inches, but it is unlikely the brief spike occurred because of total precipitation for that month. Essentially though, the well was dry for the time period.

The Penn watertable hydrograph for July-December 2000 shows five brief and relatively high spikes in the measured watertable levels. The spikes were starting from "dry" (or at least below the 20-inch deep monitoring level) and occurred in September, November, and December. Again, total precipitation can not account for these spikes. In fact, October 2000 was one of the driest months on record with only 0.16 inches of rain measured at The Plains weather station.

The Penn GWDT for July-December 2000 shows that the surface of free water.was measured in some part of the soil between 0 to 18.5 inches for 8 cumulative days, or 4% of the time. There were 2 days when the watertable level was measured between 6-12 inches below the soil surface and'6 days between 12 to 18 inches. Even these figures can be misleading. The well recorded a spike in depth to a "watertable", but the soil does not have a watertable like the Kelly sites just across the way. The Penn soil merely had a few days when enough free water was in the well to record.

Note: The Penn hydrograph and Groundwater Data Table for January-May 2001 is considered to be unreliable and is not included in this report.

CONCLUSIONS:

The Penn soil was essentially dry during the study period. There were 400 dry days out of 410 total days in the study period. The other 10 days (2% out of total days) had a very brief watertable measured in the WL-20 well. Since the well was dry for most of the time, the spikes in the watertable were always.starting from a "dry" level (if present, the watertable was about 20 inches or more below the monitoring level). The brief spikes in the watertable did not correlate well with the total precipitation recorded for the spiking months.

The Penn soil is well drained and does not have a watertable, according to the National Cooperative Soil Survey. The results of the watertable study in the Penn soil confirm the lack of a watertable. The 10 days when water was measured in the Penn monitoring well are best thought of as being jUst a snapshot of wetness with only minimal relevance to the overall hydrology for the Penn soil.

Another way to view the Penn soil and the underlying fractured shale/siltstone bedrock is that the Penn soil-bedrock continuum can absorb and transmit groundwater at a sufficient rate that does not allow for buildup of a watertable. Conversely, the adjacent Kelly soils, just a couple hundred feet away and on the same nearly level, broad summit as the Penn, soil can not absorb and transmit groundwater at a sufficient rate and a perched watertable is destined to occur. Does groundwater flow down, out, and away from the relatively permeable Penn soil-rock continuum to the slowly permeably Kelly soils? Or, does perched groundwater flow away from the Kelly soils and "disappear" into the permeable Penn soil and the underlying redbeds? The surface slope trend would seem to indicate the groundwater at the site would move towards the Kelly soils, which eventually transition into a gently sloping, upland drainageway.

If viewing the Penn soil as an either-or situation regarding presence of a watertable, the Penn soil at this site does not have a watertable. Penn still typically does not meet Virginia's minimum criteria for a conventional septic system drainfield because of shallowness to rock. (To have a conventional septic system drainfield at the Penn-Kelly study site, the Regulations would require there be 36 inches of suitable soil before encountering significant soil limitations such as bedrock or a watertable.) The Penn soil does meet the criteda for most of the alternative wastewater systems that utilize pretreatment of the septic effluent followed by an approved dispersal/disposal method. Penn is a good-fit for some of these alternative systems, such as spray irrigation.

In a backhanded way, the Kelly and/or Jackland soils control use of the Penn soil for an onsite wastewater system. Because Kelly and Jackland soils have a perched watertable and are on the same nearly level and gently sloping landforms as the Penn soil, it is critical to determine if there are any Kelly and/or Jackland soil inclusions within any Penn site proposed for an onsite was{ewater system. This ultimately means reviewing any available geology maps prior to evaluating the Penn site to see if there are any igneous intrusions in the general soil area. Also, as with any scaled map, all the igneous intrusions can not and will not be shown in an area, making a thorough field evaluation the best determination of all.

Penn loam

Soil Profile for Well # 1 (WL-20)
A--0 to 2 inches; dark brown (7.5YR 3/2) loam; moderate fine granular stricture; friable; non sticky, non plastic; 2 to 5% shale gravel; clear smooth boundary.

AB--2 to 9 inches; dark brown (7.5YR 3/3) gravelly loam; moderate fine and medium granular strUcture; friable; slightly sticky, non plastic; 10 to 15% shale gravel; clear wavy boundary.

Bt1--9 to 16 inches; reddish brown (5YR 4/3) channery light clay loam; weak fine and medium subangular blocky structure; friable; sticky, slightly plastic; 20 to 30% shale channers and gravel in a mostly bedded pattern; clear gradual boundary.

CBt--16 to 28 inches; reddish brown (5YR 4/3) very channery clay loam or silty clay loam; rock controlled structure; soil materials friable, sticky, and slightly plastic; 55 to 65% shale or siltstone in a bedded pattern.

Cr--28 to 32 inches; dark reddish brown (5YR 3/3) shale or siltstone weathered bedrock; most rock faces have reddish brown (5YR 4/3) silt loam to light silty clay loam coatings; common to many black (7.5YR 2/0) manganese coatings on rock faces; general shovel rejection becaUse of bedrock.

Remarks: Profile was described using a shallow backhoe pit that was about 15 feet away from the WL-20 monitoring well. The landform is a nearly upland fiat with slopes ranging from 0 to 2%. Soils in the general area are mapped as Penn and Kelly in the Fairfax and Loudoun County Soil Surveys.

Table I - - Penn loam Groundwater Data Table
November - December, 1999 (44 Days)
Fairfax County, Data Logger f~l (WL-20)

Well # 1

Depth Range (in.)	Number of Days	Percent Time	Cumulative Days	Percent Cumulative Days
0-6	0	0	0	0
6.1-12	0	0	0	0
12.1-20	0	0	0	0
DRY	44	100	,44	100
24.1-30	-			

Table 2 - - Penn loam Groundwater Data Table
January- June, 2000 (182 Days)
Fairfax County, Data Logger Well # 1 (WL-20)

Well # 1

Depth Range (in.)	Number of Days	Percent Time	Cumulative Days	Percent Cumulative Days
0-6	0	0	0	0
6.1-12	0	0	0	0
12.1-19.1	2	1	2	
DRY	180	99	182	100

24.1-30 .....
30.1-36 ....
36.1-40 ......
L DRY .....

Number of Days column refers to the number of days the surface of the free water was present within the depth range.
Percentage of Time column refers to the percent of time the water was present within the depth range.
Cumulative Days column refers to the total number of days the water was present within the depth range.
Percentage of Cumulative Days refers to the percent of total time the water was present within the depth range.
DRY corresponds to the number of readings (converted to days) where the monitoring well recorded no water in the hole.
Days in the column headings corresponds to the number of data logger readings within a depth range

divided by the number (normally 2, 4 or 8) of data logger readings per day.

Table 3 - - Penn loam Groundwater Data Table
July - December, 2000 (184 Days)
Fairfax County, Data Logger # 1 (WL-20)

Well # 1

Depth Range (in.)	Number of Days	Percent Time	Cumulative Days	Percent Cumulative Days
0-6	0	0	0	0
6.1-12	2	1	2	1
12.1-18.5	6	3.	8	4
DRY	176	96	184	100
24.1-30	....			
30.1-36	....			
36.1-40	.....			
DRY	....			

Number of Days column refers to the number of days the surface of the free water was present within the depth range.
Percentage of Time column refers to the percent of time the water was present within the depth range..
Cumulative Days column refers to the total number of days the water was present within the depth range.
Percentage of Cumulative Days refers to the percent of total time the water was present within the depth range.
DRY corresponds to the number of readings (converted to days) where the monitoring well recorded no water in the hole.
Days in the column headings corresponds to the number of data logger readings within a depth range divided by the number (normally 2, 4 or 8) of data logger readings per day.

**Table 4 - Penn loam - Days Surface of Free Water Measured in Depth Range
(410 Days)

Depth Range (in.)	Nov-Dec 99	Jan-Jun 00	Jul-Dec 00	Jan-May 01	Total Days	% Total Days
0-6	0	0	0	-	0	0
6.1-12	0	0	2	-	2	0
12.1-19	0	2	6	-	8	2
DRY	44	180	176	-	400	98
24.1-30	......					
30.1-36	......					
36.1-40	......					
DRY	......					

** For other soils in the study, this table is generally described in the narrative.

Fairfax County Water Table Monitoring Sites
at Fairfax National Golf Course

not to scale

-'- - loo'

~_~ Well # 2
40 inch datalogger

2'

Wooded

Kelly Soil
Well # 1
40 inch datalogger

163'

Mass Drainfield

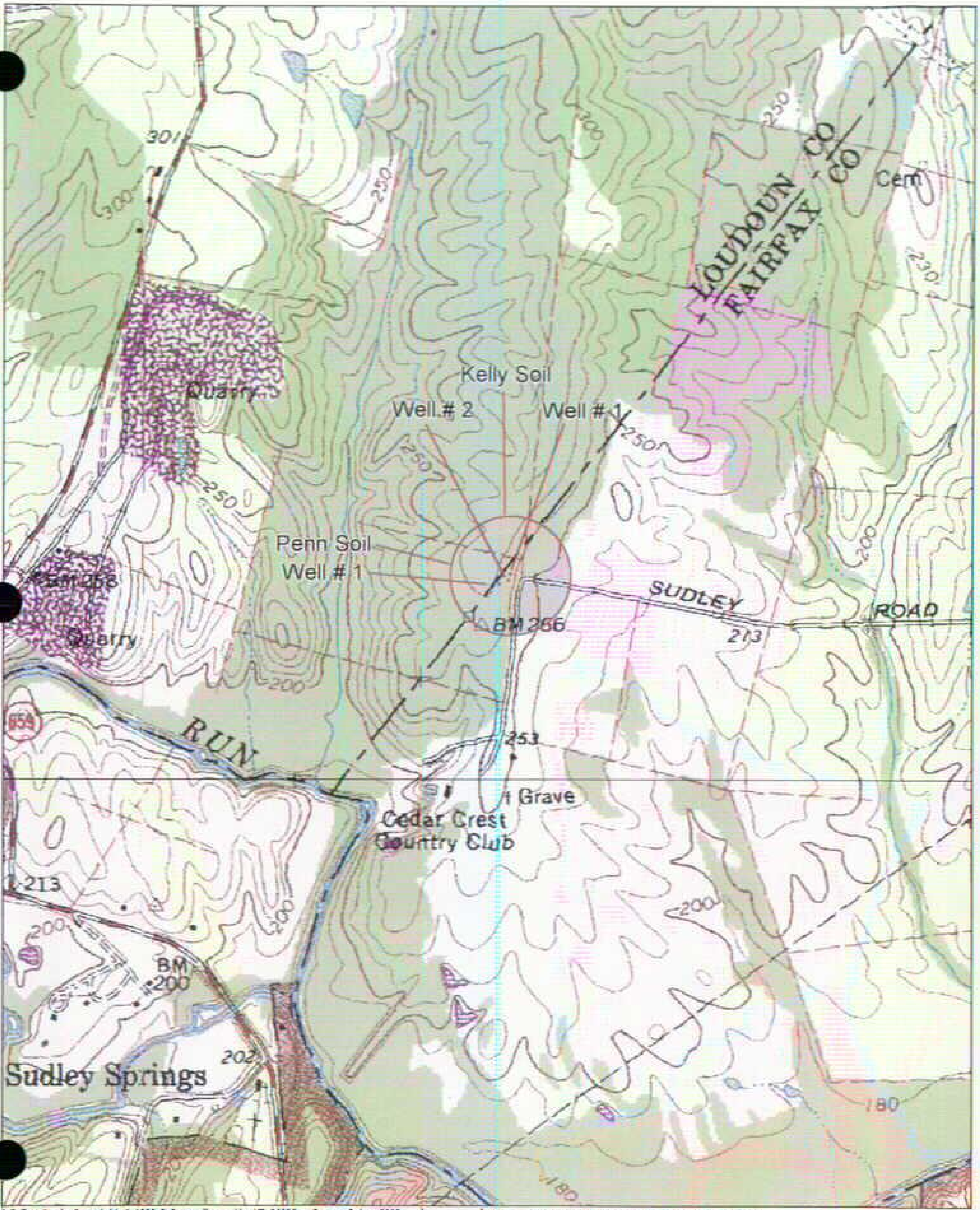
Penn Soil
Well # 1
20 inch datalogger

'145'

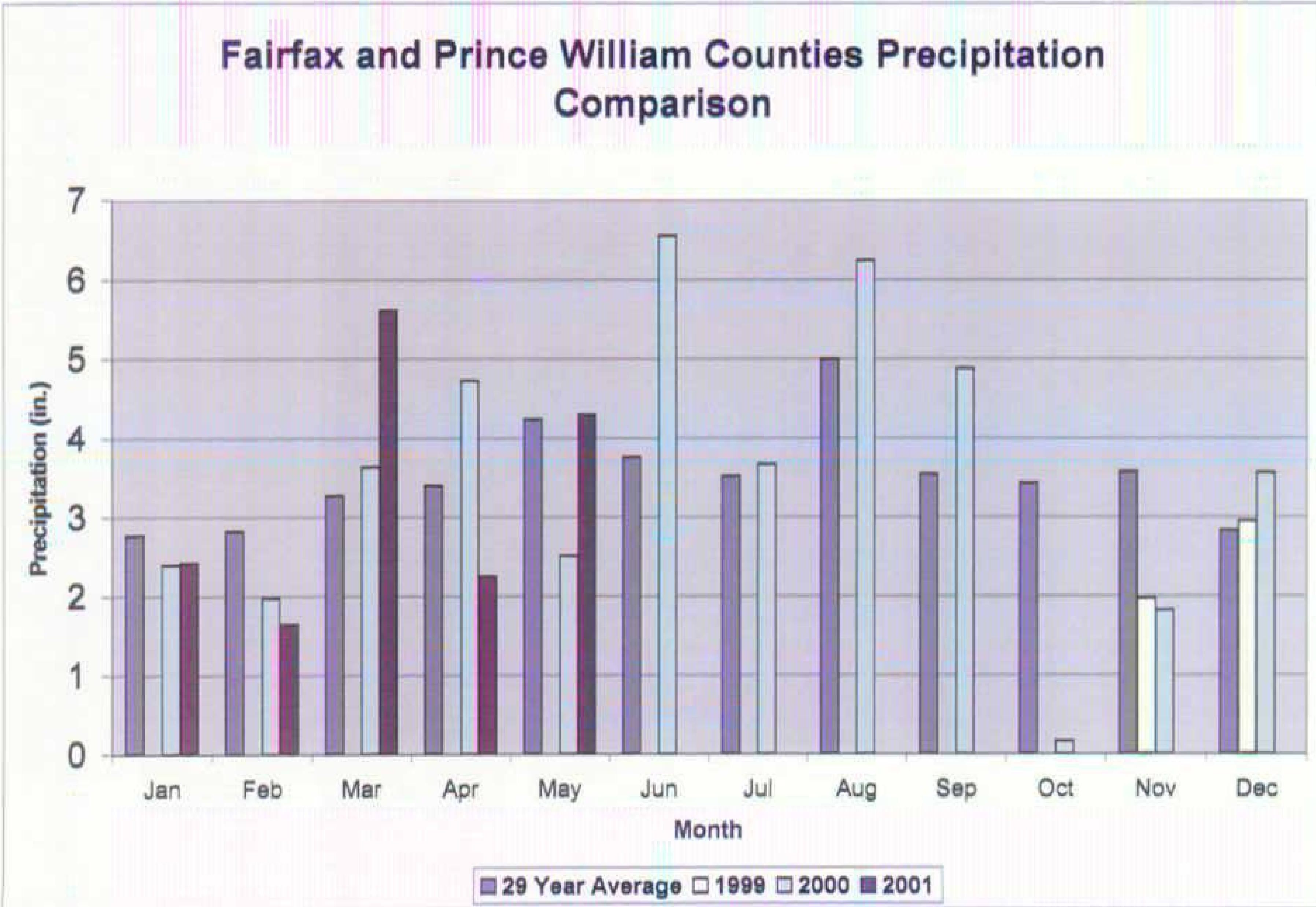
Dirt Road

Hangaflshed

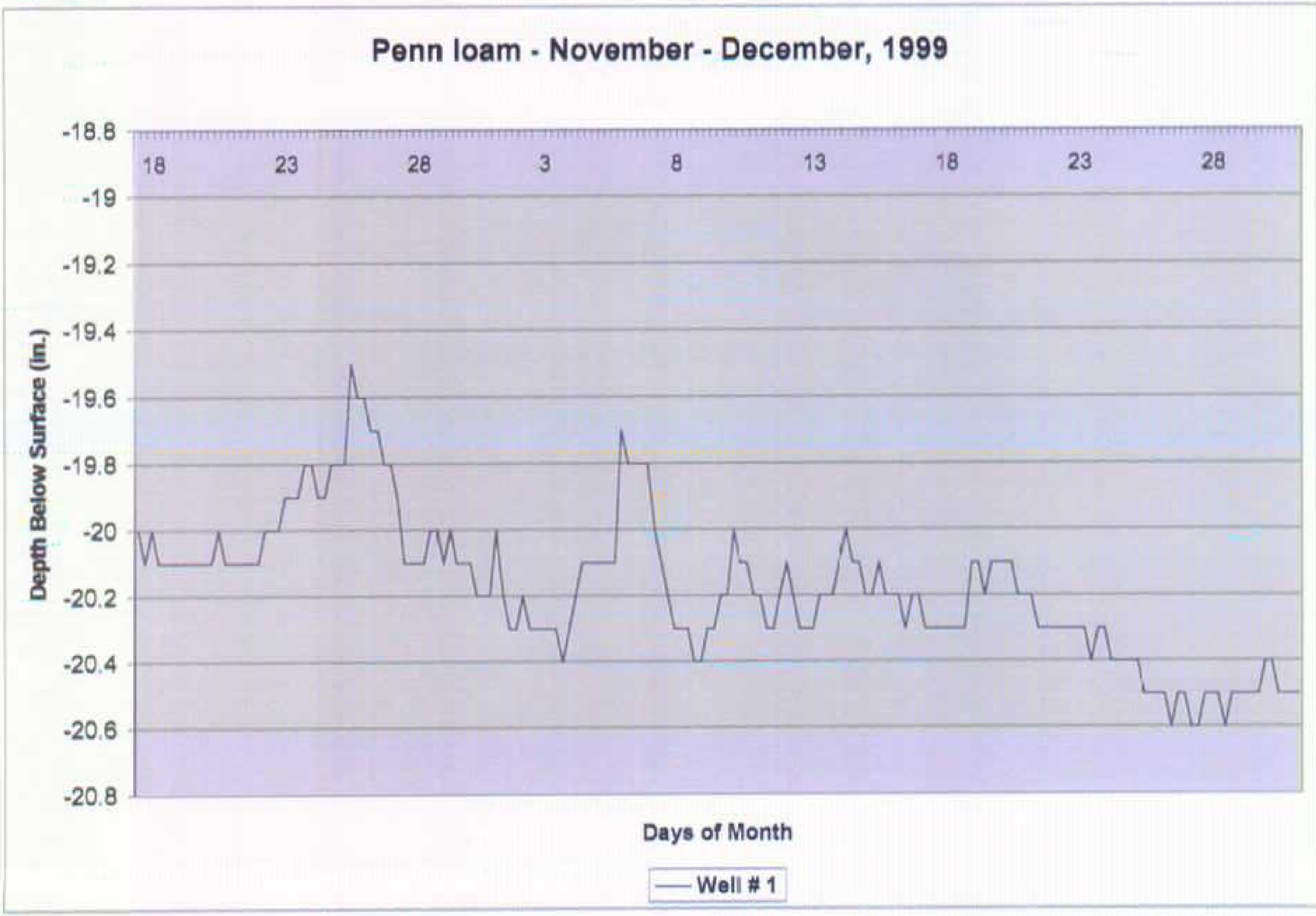
250' x 80'



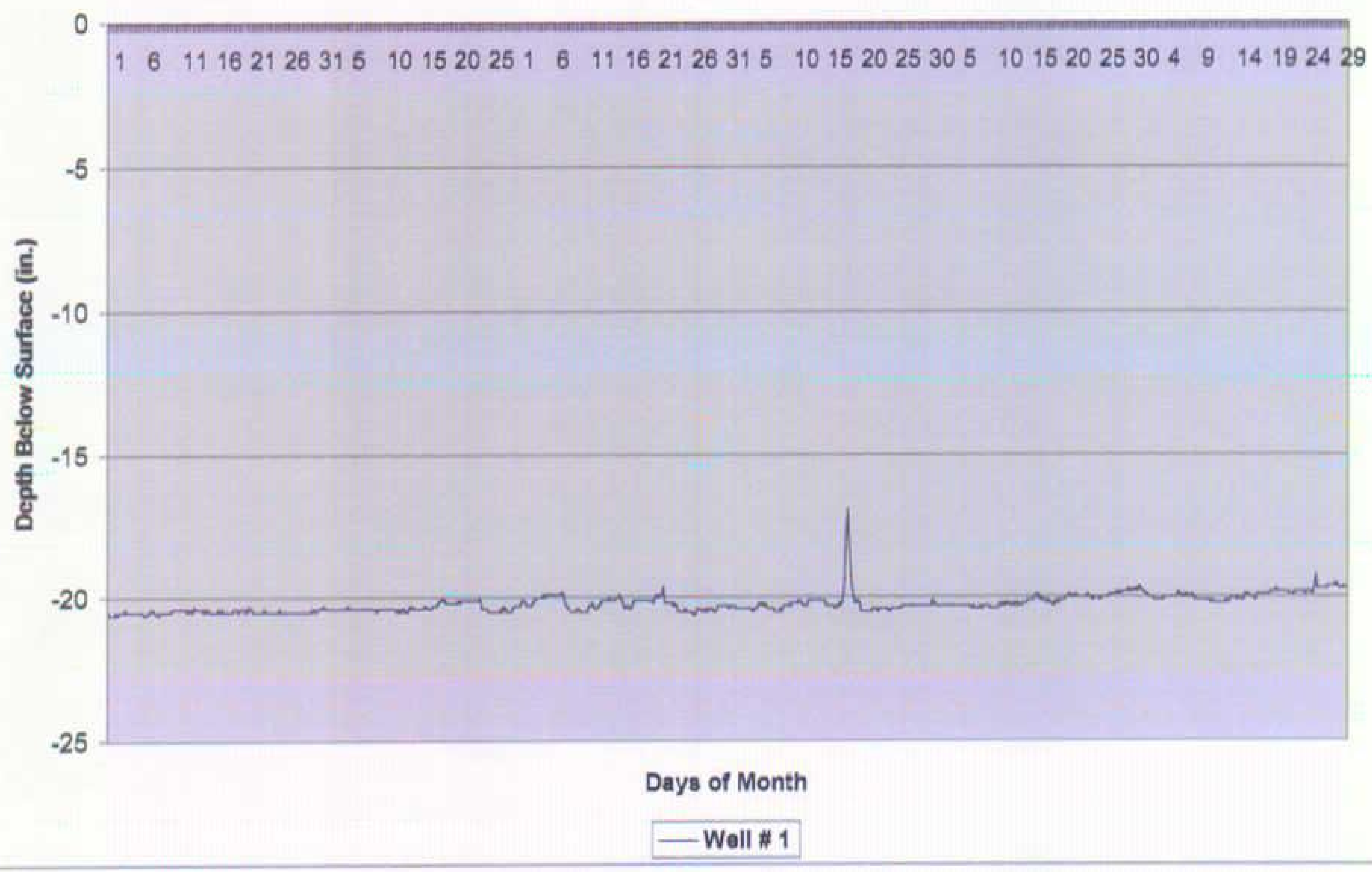
 500 ft Scale: 1 : 12,800 Detail: 14-0 Datum: WGS84

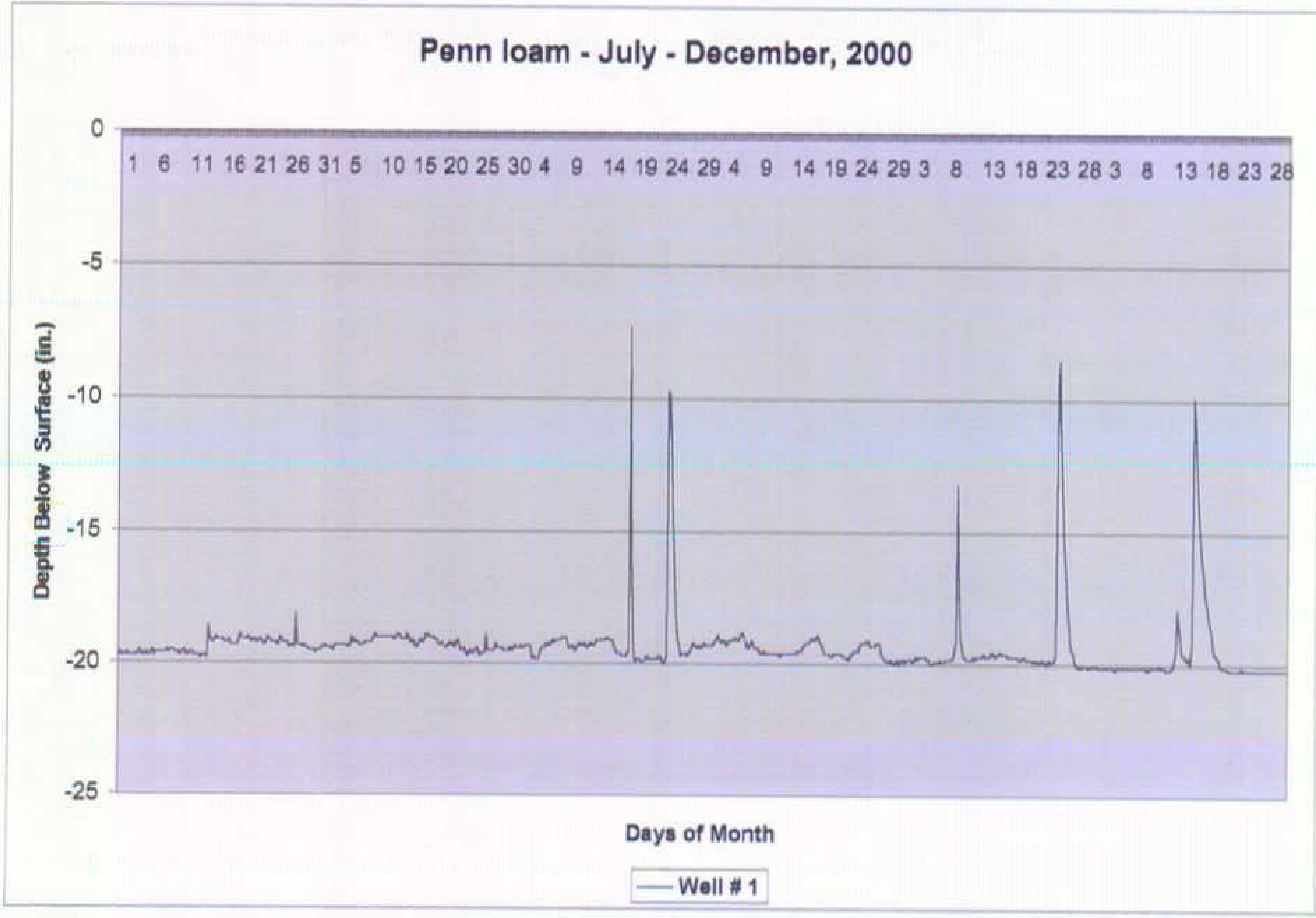


Fairfax and Prince William Counties Precipitation Comparison
Precipitation (in.)
0
1
2
3
4
5
6
7
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month
29 Year Average
1999
2000
2001


Penn loam - November - December, 1999
Depth Below Surface (in.)
-18.8
-19
-19.2
-19.4
-19.6
-19.8
-20
-20.2
-20.4
-20.6
-20.8
18
23
28
3
8
13
18
23
28
Days of Month
Well # 1

Penn loam - January - June, 2000





Penn loam - July - December, 2000
0
-5
-10
-15
-20
-25
Depth Below Surface (in.)
1 6 11 16 21 26 31 5 10 15 20 25 30 4 9 14 19 24 29 4 9 14 19 24 29 3 8 13 18 23 28 3 8 13 18 23 28
Days of Month
Well # 1

SOIL EVALUATED: Spotsylvania-like sandy loam

LOCATION:

This research site was located in the southern portion of Chesterfield County, Virginia. Refer to the accompanying portion of the Beach U.S. Geologic Survey topographic map for the general character of the area. The accompanying. detailed site sketch shows the location of two WL-40 automated data loggers, and a deep manual observation well in Pocahontas State Park.

RATIONALE FOR SITE SELECTION:

There were several reasons for using this site. First, because the site had significant relief, the effects of topographic landscape position on water table could be assessed. Second, this site had been used in the past for training of Virginia Department of Health staff working in the onsite wastewater program, so information was available to supplement the water table readings. And finally, since there are so many acres of Piedmont soils with overlying fluvial sediments (ie, capping materials), a water table study might provide information on how wet these soils really are and how well suited they might be for onsite wastewater disposal systems.

SOIL AND SITE INFORMATION:

The soils'at this site formed in moderately-fine .textured',' stratified;' unconsolidated, fluvio-marine sediments overlying material weathered-in-place (residuum) from granite or granite-gneiss. There was a narrow summit, on which Trail #352 was located, and the uphill WL-40 was located just downslope of the summit on a shoulder landscape position. There was a long, gently sloping hillside, and the downhill WL-40 was located on that sideslope, about 200 feet downslope of the deep manual observation well. Near the downhill WL-40 well was a backhoe pit, which had been used for a detailed profile description and soil sampling for laboratory analysis. The wells were in the woods.

The Soil Survey of Chesterfield County, Virginia (Robert L. Hodges, 1978), shows the research site as being mapped as Appling-Spotsylvania sandy loams, 2-6% slope (245B). While the thickness of the fluvial capping is greater than normal for Spotsylvania soils, this would have been considered an inclusion in the mapping unit.

Detailed soil profile descriptions were made at both the uphill and downhill sites and are included. When compared to the official soil series description for the

Spotsylvania series (refer to the Appendix), the soils at this site fall outside the range of characteristics. That means the soils studied were not typical of Spotsylvania soils. That's because these soils had a thicker capping of transported sediments than normal and the subsoil was thicker than normal.

Therefore, these soils are Spotsylvania-like. Since the Emporia soil sedes had not been established when .the soil survey was completed, the area was included in Spotsylvania, the most similar soil available. The soils studied at this site were representative of Emporia soils.

CLIMATIC DATA FOR THE SITE:.

The site was approximately 18 miles from the Richmond International Airport, where official NOAA weather data were collected, so precipitation data from the . airport was used to evaluate long-term rainfall averages during the study period. Local rainfall was measured at the Chesterfield Courthouse Complex, only 6 miles from the study site. The precipitation comparison graph shows how each month's rainfall compares to the monthly 29-year averages (1961-1990).

Precipitation in January 2000 was above normal due to heavy snows late in the month, while April 2000 was 2.73 inches above normal. For the period January-June 2000, total precipitation was 2.2 inches above the 29-year average. While there was a drought in 1999, water table levels would be expected to be representative of normal conditions at the site.

For the period July-December 2000, monthly rainfall was well above average in July and August. No rainfall was recorded for the entire month of October 2000, making it the driest October since data collection began in 1928 at the Richmond International Airport. The October-December 2000 period was extremely dry. In fact, rainfall was only 40% of the long-term average for that 3 month span. Therefore, the water table levels at the site would be expected to be shallower (nearer the surface) during a fall with nOrmal precipitation.

For the period January-June 2001, rainfall was generally below normal. March and June 2001 had well above normal rainfall totals, while other months were below normal. January-May 2001 rainfall was 2.22 inches below the 29-year average, or 13% below normal. Therefore, the water table levels at the site would be expected to be shallower during a winter and spring with normal precipitation.

Except for a few exceptional wet months (January, April, July and August 2000; March and June 2001), precipitation was normal to below normal. It should be noted that the original project completion date was extended due to severe drought conditions in most of the state during 1999. Fall 2000 thru spring 2001 was also well below normal. Therefore, only the January-June 2000 period had near normal precipitation, while the rest of the study period had below normal rainfall.

RESULTS:

Two WL-40 automated data loggers were installed on January 11, 2000. A deep manual observation well (10 feet deep) was installed on January 10, 2000. The uphill wells were installed in the same soil, on the same landscape position, and at the same topographic elevation. The downhill WL-40 well was installed in similar soil to the uphill site. Collection of water table data began on January 11, 2000. There was continuous data collection from the starting date until June 30, 2001. The manual well was read only when visiting the site to download data from the data loggers. The manual well was not intended to gather water table data on a frequent basis.

The Spotsylvania-like soil at the uphill site had common light gray (10YR 7~2) mottles (or iron depletions) below 40 inches, and the downhill site had common light brownish gray (10YR 6/2) mottles below 60 inches, making them well drained soils. Normally, it would be assumed that the seasonal water table would be below 40 or 60 inches, respectively, while there might be brief periods where it was above those depths. These soils normally have a perched water table. The lower subsoil horizons were dense, red mottled and restrictive, which was confirmed by the soil profile description remarks made for this site (ie, the Bt3 horizons were dense and hard to auger)..The mottling at shallower depths in the Bt2 horizons was suspected to be associated with the fluctuating seasonal water table, perched above the Bt3 horizon.

No water was ever recorded in the uphill WL-40 well during the entire study period. Therefore, no hydrographs or data tables are included for that monitoring well in this report.

The January-June 2000 hydrograph for the downhill site shows there was a brief period where a water table was present (8 days) in mid-April. Otherwise, the data logger remained dry for 95% of this period.

No water was recorded in the downhill WL-40 well during July-December 2000, so no hydrograph or data tables are included for that monitoring well in this report.

The January-June 2001 hydrograph for the downhill site shows there was a brief period where a water table was present (5 days) in late March. Otherwise, the data logger remained dry for 97% of this period.

The deep manual well was installed to verify the assumption that the saprolite below the capping materials was well drained. That would be important to ascertain, since conventional septic systems are commonly installed deep into saprolitic materials. The deep manual well remained dry until April 19,2000 when 54 centimeters of free water was recorded in the bottom of the hole. As much as

72 centimeters of water was recorded in the well, but by May 11,2000 the hole was drY. The deep manual well was then dry for the remainder of the study. The presence of free water in the deep manual well does not correspond to any water table readings in the adjacent WL-40 well. However, the water in the manual well does correspond to the brief pedod when free water was observed in the downhill WL-40 well. Because of drY conditions in early 2000, it may be possible that the bentonite grout had not completely swollen to seal the annular space around the plastic pipe. Due to the presence of restrictive horizons in the lower portion of the capping and upper residual materials, it would be reasonable to assume that the period of free water observed in the deep manual observation well was due to perched waters flowing down the outside of the plastic pipe and briefly accumulating in the bottom of the hole.

CONCLUSIONS:

This site had precipitation well below normal for the majority of the study period. In spite of that, it was anticipated that there would be free water for extended periods in the automated data loggers, especially the downhill site. However, except for two brief periods totaling 13 days, no water was observed in the data loggers during the entire 18-month study.

It appears that the dissected landscape at the site reduced the size of the watershed, therefore significantly reducing the amount of water available to accumulate in these Spotsylvania-like soils. The lack of water in the uphill WL-40 can be explained because the well was immediately adjacent to a narrow summit, so there was almost no upslope watershed to supply perched waters to the monitoring well. Therefore, it appears that the presence of mottles at the uphill site did not relate to current soil wetness.

However, there was a long watershed above the downhill WL-40, and some brief water table readings were recorded. It may be that the shallow surface ditches next to Fire Route #350 were highly effective in diverting water (surface and subsurface) away from the area, and effectively preventing the build-up of a water table at the downhill site. As was the case with the uphill site, it appears that the presence of mottles in the downhill site did not relate to current soil wetness.

Therefore, the two Spotsylvania-like soils studied at this site were well drained, and the strong brown and/or verY pale brown mottles observed did not relate to any significant periods of soil saturation. It also .appears that landscape dissection (ie, drainage) may have significantly altered the normal soil hydrology at the site. These soils would be suitable for septic system use in both the upper

Coastal Plain capping sediments or in the deep loamy granitic saprolite.

While there was a brief period where free water was observed in the deep manual observation well, it appeared to be related to temporarily ineffective grouting, not due to a seasonal water table in the saprolite. 'It appears that the deep loamy saprolitic materials were well drained, and would be suitable for septic system use.

Spotsylvania-like sandy loam

Soil prOfile for Upslope WL-40 Well and Deep Manual Well

A--0 to 3 inches, brown (10YR 4/3) sandy loam; many very fine and common fine roots; very friable, nonsticky, nonplastic, slightly fluid; moist.
E--3 to 14 inches, light yellowish brown (10YR 6/4) sandy loam; few fine round quartz pebbles; few fine roots; very friable, nonsticky, nonplastic, slightly fluid; moist.

Bt1~14 to 23 inches, yellowish brown (10YR 5/8) clay loam; very few fine roots; firm to friable, moderately sticky, moderately plastic, slightly fluid; moist.
Bt2--23 to 40 inches, yellowish brown (10YR 5~8) clay loam; few fine round quartz pebbles; common medium distinct strong brown (7.5YR 5/8) masses of iron accumulation; very few fine roots; firm, moderately sticky, moderately plastic, slightly fluid; slightly moist.

Bt3---40 to 58 inches, yellowish brown (10YR 5/8) clay loam; few subrounded very coarse quartz sand grains; common medium distinct strong brown (7.5YR 5~8) and common medium prominent red (2.5YR 4/8) masses of iron accumulation, and common medium prominent light gray (10YR 7~2) and few medium distinct yellow (10YR 7/6) iron depletions; firm, moderately sticky, moderately plastic, slightly fluid; extremely hard to auger- auger jumps or skips in hole when digging; dry.

2BCt~58 to 81 inches, red (2.5YR 4/8) and brownish yellow (10YR 6/8) clay loam; note angular quartz sand grains; common medium distinct strong brown (7.5YR 5/8) masses of iron accumulation, and few medium prominent light gray (10YR 7/2)iron depletions along ped faces; common pockets of white (10YR 8/2) granite saprolite (feldspar derived); common unmottled yellowish brown (10YR 5/4) clay flows; very hard dry consistence, moderately sticky, moderately plastic, slightly fluid; dense-in-place and auger jumps in hole when digging; the red zones are only moderately hard and see very fine mica flakes increasing with depth, while the white zones are very hard; dry.

2C1--81 to 95 inches, red (2.5YR 4/8) and yellow (10YR 7/8) light clay loam; common pockets of white (10YR 8/2) granite saprolite (feldspar derived); few unmottled strong brown (7.5YR 5~6) clay flows on ped faces and in the white saprolite pockets; the consistence of the red & yellow soil is slightly hard, moderately sticky, slightly plastic, slightly fluid; the consistence of the white soil is. very hard, moderately sticky, moderately plastic, slightly fluid; note angular quartz sand grains and a heavy clay loam texture in the white saprolite pockets; see mice flakes in the red & yellow soil areas; easier to auger than the Bt3 or the 2BCt horizons; dry.

2C2--95 to 132 inches, red (10R 4/6 & 4/8) loam; common white (10YR 8/1) granite sa~)rolite pockets; few brownish yellow (10YR 6/6) parent material mottles; very few fine roots; many very fine mica flakes; very fdable, moderately to slightly sticky, nonplastic; harder to auger when encounter the white (clay loam) pockets, but they contained unmottled strong brown clay flows; moist. Remarks: Auger description from 0-132 inches, taken midway between a data logger and a deep manual well. Profile taken in woods under oak trees. 1% slope. Landscape postion- shoulder or crest position, adjacent to narrow summit. Profile described on May 15,2000.

Spotsylvania-like sandy loam

Soil Profile for Downslope WL-40 Well

Al--0 to 2 inches, dark grayish brown (2.5YR 4~2) sandy loam; clear wavy boundary; moist.

A2--2 to 7 inches, brown (10YR 5/3) sandy loam; weak fine subangular'blocky structure; few coarse, and many medium, and fine and very fine roots; very friable, slightly plastic, nonplastic; clear wavy boundary; moist.
E--7 to 23 inches, light yellowish brown (10YR 6~4) sandy loam; weak medium subangular blocky structure; few coarse, and common medium, and few fine roots; very friable, slightly sticky, slightly plastic; common very fine, and few fine pores; gradual wavy boundary; moist.

Btl--23 to 33 inches, yellowish brown (10YR 5/8) sandy clay loam; weak medium subangular blocky (and few weak fine subangular' blocky) structure; common fine, and few medium roots; friable, sticky, plastic; few medium, and Common fine, and many very fine pores; clear wavy boundary; moist.

Bt2~33 to 40 inches, yellowish brown (10YR 5/6) clay loam to sandy clay loam; common medium distinct strong brown (7.5YR 5/8) masses of iron depletion; weak medium subangular blocky structure for the yellowish brown matrix; note that the strong brown zones are fine subangular blocky structures that are noticeably more resistant to pressure; few fine roots; firm to friable, sticky, plastic; few fine and very fine pores; gradual wavy boundary; moist.

Bt3--40 to 60, yellowish brown (10YR 5/6) sandy clay loam; cbmmon medium distinct strong brown (7.5YR 5/8) and common fine prominent red (2.5YR 4~8) masses of iron accumulation, and few very pale brown (10YR 7/4) iron depletions (along rootS); moderate coarse platy structure parting to moderate fine subangular blocky structure (note that the platy structure is not parallel to the

land surface- there is a distinct dip to the structural units); few fine roots; firm, stidky, plastic; few very fine pores; observed a moist 10YR 5/6 tongue of the Bt2 extending down into the Bt3 that had a dnd of 7.5YR 5/8 surrounding it; noted a brittleness to the soil samples and was difficult to auger; damp.

2C1~0 to 84 inches, strong brown (7.5YR 5/8) clay loam; many coarse prominent red (10R 4/8) masses of iron accumulation, and common coarse distinct light brownish gray (10YR 6/2) iron depletions; moderate medium and coarse platy structure, with common extremely hard nodular-like peds; firm to very firm, sticky, plastic; common coarse mica flakes; common very fine light gray (10YR 7/1) granite saprolite (feldspar derived) flecks or mottles; common very thick, extremely firm light gray (10YR 7/1) clay saprolite (feldspar derived) seams or flows below 70 inches- these seams often have strong brown coatings on ped faces; extremely hard to auger- auger skipping in hole as digging; barely damp.

2C2--84 to 102 inches, brownish yellow (10YR 6/8) sandy clay loam; common medium prominent red (2.5YR 4/8) parent material mottles; many white (10YR 8/1) clay loam saprolite (feldspar) seams or pockets; common fine mica flakes; easier to auger; dry.

2C3--102 to 120 inches, red (2.5YR 5/8) sandy clay loam; many medium prominent yellow (10YR 7/8) parent material mottles; many white (10YR 8/1) clay loam saprolite (feldspar) seams or pockets; few mica flakes seen in the white -saprolite pockets; red soil areas are friable, while the white clayey areas are firm; dry.

Remarks: Upper soil profile to a depth of 54 inches described from a pit, auger hole description from 54-120 inches. Profile taken in woods under oak trees. 3-4% slope. Landscape position- sideslope. Profile described on February 3,1989. Particle size analysis data for selected horizons: E- 68% sand, 26% silt, 6% clay, which is a sandy loam. Bt1- 57% sand, 20% silt, 23% clay, which is a sandy clay loam. Bt3- 57% sand, 18% silt, 25% clay, which is a sandy clay loam.

Table I - - Spotsylvania sandy loam Groundwater Data Table
January - June, 2000 (172 Days)
Pocahontas State park, Data Logger Well # 1

Well # 1

Depth Range (in.)	Number of Days	Percent Time	Percent Cumulative Days	Cumulative Days
0-6	0	0	0	0
6.1-12	0	0	0	0
12.1-18	0	0	0	0
18.1-24	0	0	0	0
24.1-30	1	1	1	1
30.1-36	4	2	5	3
36.1-40	3	2	8	5
Dry	164	95	172	100

Table 2 - - Spotsylvania sandy loam Groundwater Data Table
January - June, 2001 (181 Days)
Pocahontas State Park, Data Logger Well # 1

Well # 1

Depth Range (in.)	Number of Days	Percent Time	Percent Cumulative Days	Cumulative Days	
0-6	0	0	0	0	
6.1-12	0	0	0	0	
12.1-18	0	0	0	0	
18.1-24	1	I	1	1	
24.1-30	1	I	2	1	
3O. 1-36	1	1	3	2	-
36.1-40	2	I	5	3	
Dry	176	97	181	100	

~ Number of Days column refers to the number of days the surface of the free water was present within the depth range.
Percentage of Time column refers to the percent of time the water was present within the depth range.
Cumulative Days column refers to the total number of days the water was present within the
· depth range.
Percentage of Cumulative Days refers to the percent of total time the water was present within the depth range.

DRY corresponds to the number of readings (converted to days) where the monitoring well recorded no water in the hole.
Days in the column headings corresponds to the number of data logger readings within a depth range divided by the number (normally 2, 4 or 8) of data logger readings per day.

Pocahontas State Park

,~,_,, C~o, "'-~ ~C'
WL40 vv~ ~;~ ~,,~ ,
Backhoe Pit Deep
,, Manual
Well

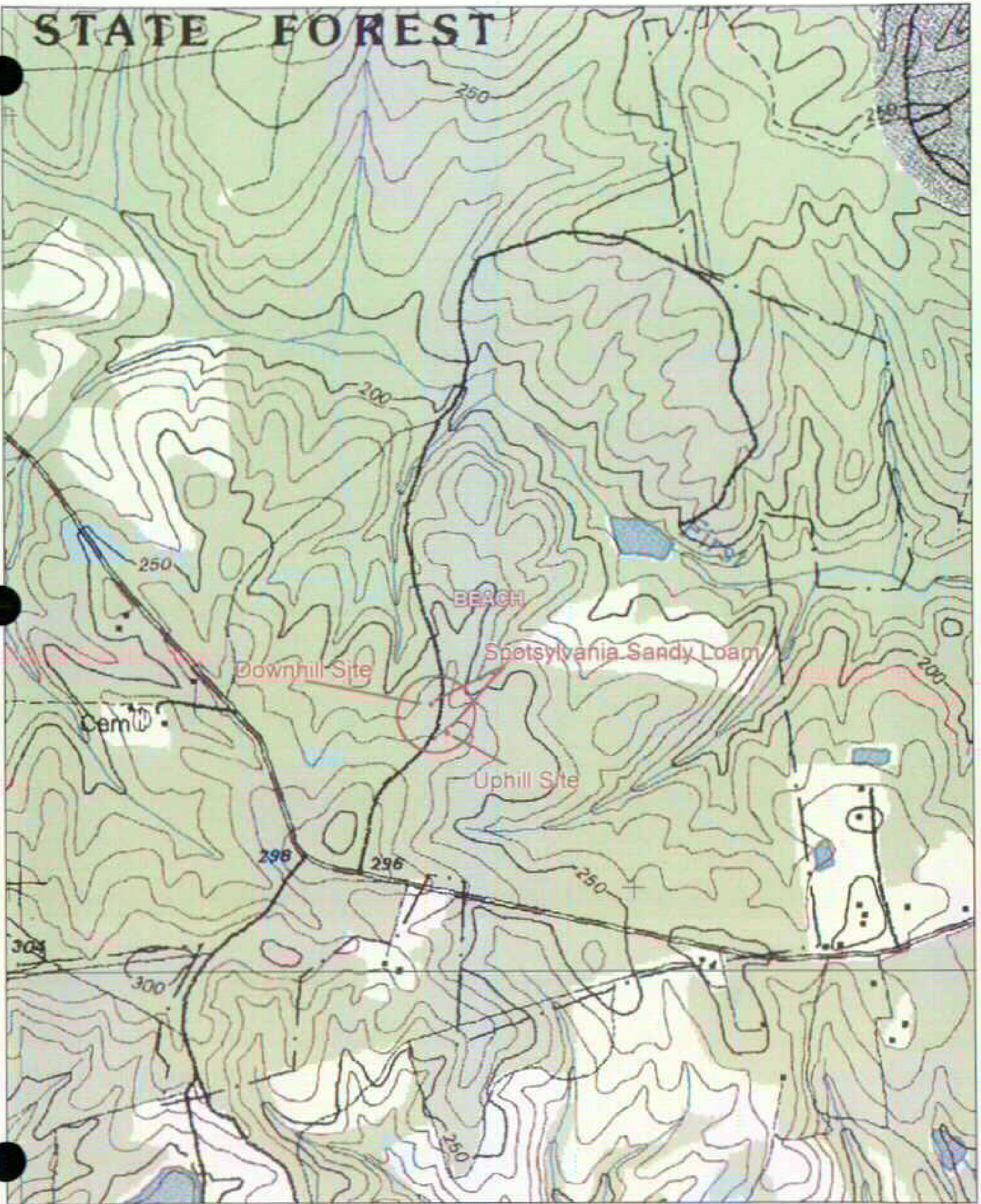
WL4(

woods

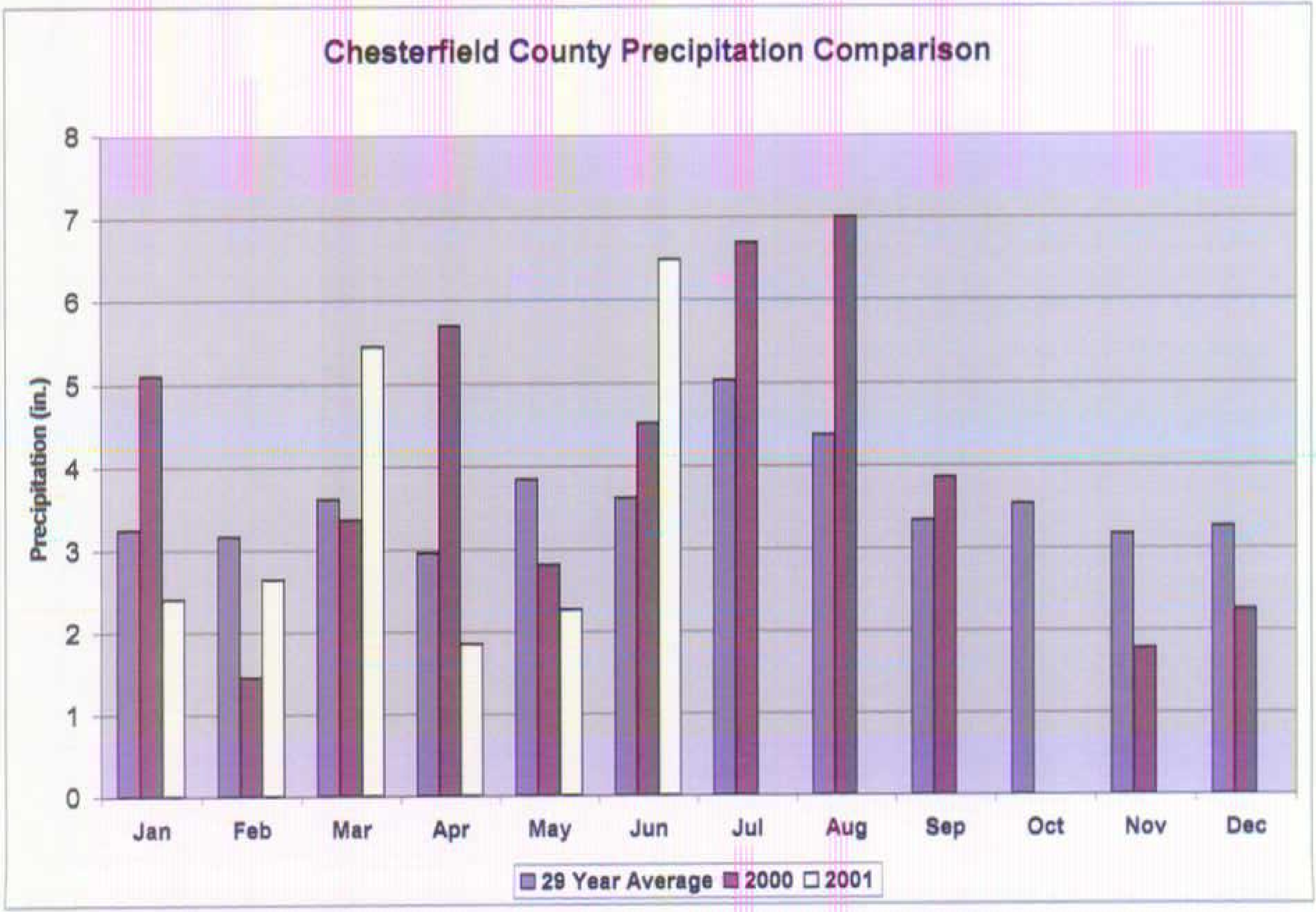
woods
woods .~/

Not to Scale

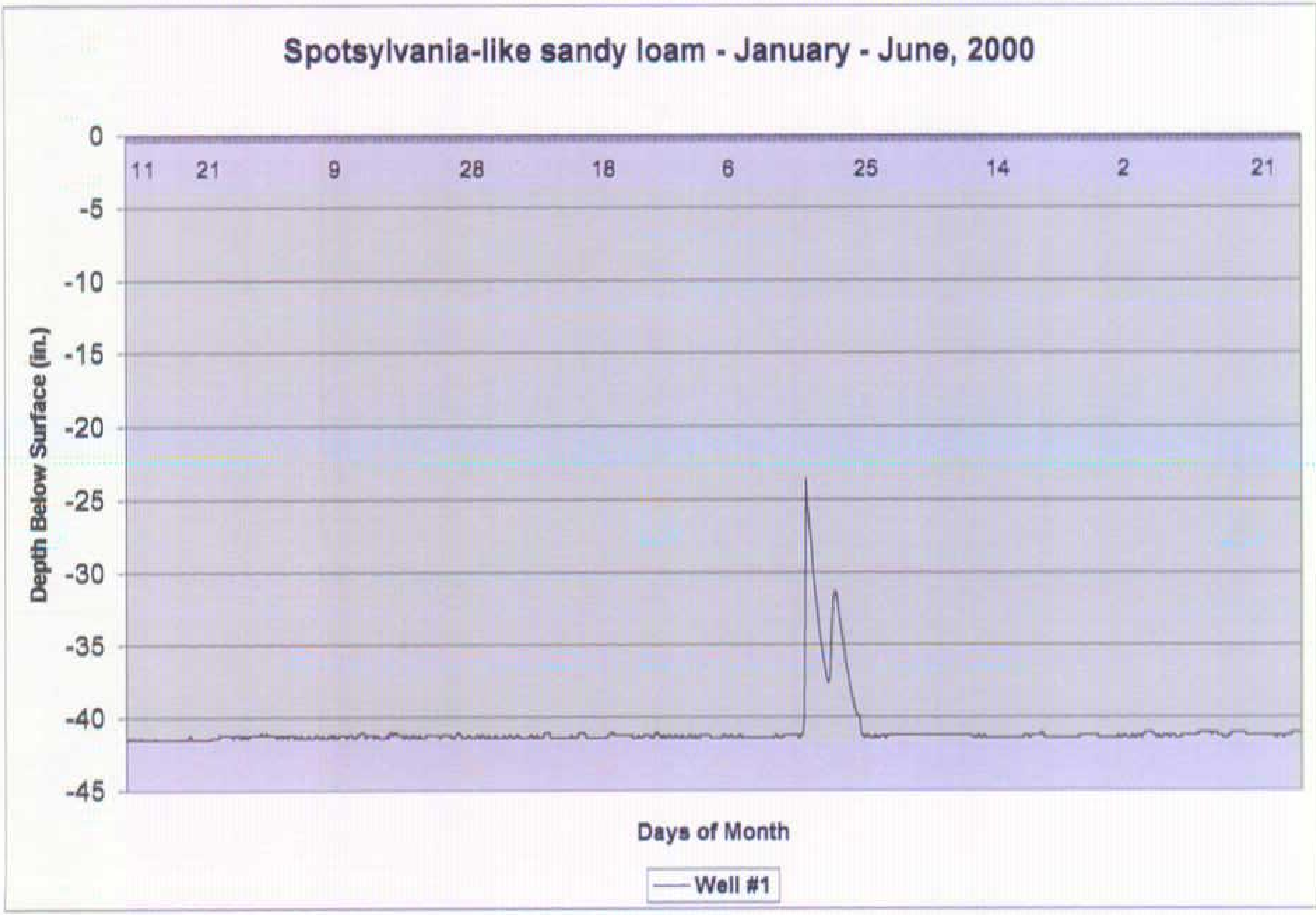
Woodpecker Road to Nash Road



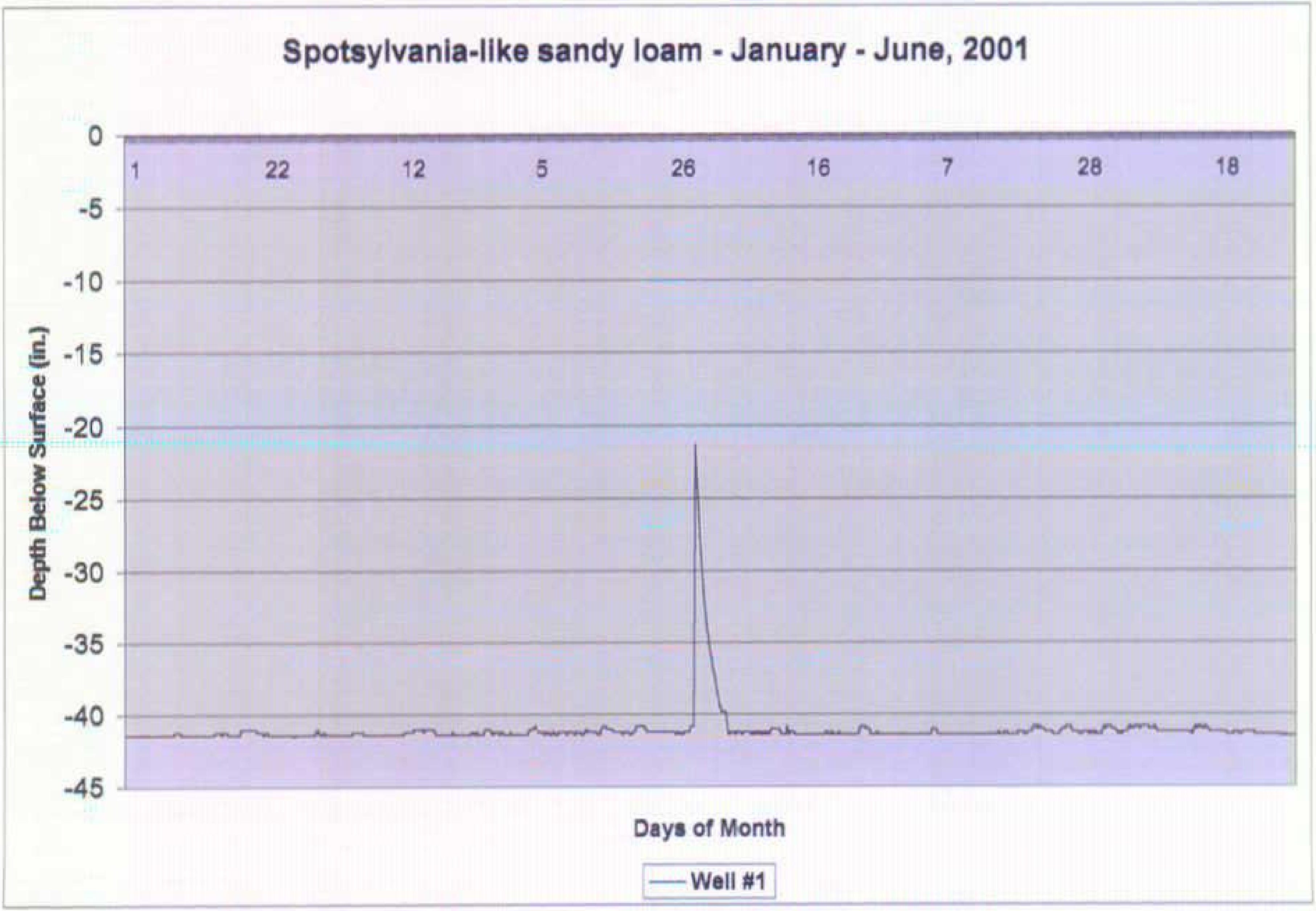
STATE FOREST
250
200
250
BEACH
Spotsylvania Sandy Loam
Downhill Site
Uphill Site
Cem
200
298
296
250
304
300
250



Chesterfield County Precipitation Comparison
Precipitation (in.)
8
7
6
5
4
3
2
1
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
29 Year Average
2000
2001



Spotsylvania-like sandy loam - January - June, 2000
Depth Below Surface (in.)
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
11
21
9
28
18
6
25
14
2
21
Days of Month
Well #1



Spotsylvania-like sandy loam - January - June, 2001
Depth Below Surface (in.)
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
1
22
12
5
26
16
7
28
18
Days of Month
Well #1

SOIL EVALUATED: Yemassee fine sandy loam

LOCATION:

This research site was located in the northern portion of Isle of Wight County, Virginia. Refer to the accompanying portion of the Benns Church U.S. Geologic Survey topographic map for the general character of the area. The accompanying detailed site sketch shows the location of two automated WL-40 data loggers on this potential residential property (vacant lot).

RATIONALE FOR SITE SELECTION:

There were several reasons for using this site. First, the type of soil at the site, Yemassee, represents a major soil type located over large areas-in the state. To study it would provide valuable information that could apply to numerous sites considered for onsite septic systems. Second, while the Yemassee soil does not meet Virginia criteria to allow installation of a conventional gravity drainfield, it does allow for permitting of certain alternative type systems. And finally, the proposed resident at this site requests an alternative onsite wastewater disposal system. Therefore, a water table study would be required to provide information on how well an alternative type system works in this problem soil and what type of system would best be used.

SOIL AND SITE.INFORMATION:

The soil at this site formed in moderately coarse textured, stratified, unconsolidated, fiuvio-marine sediments of the middle Coastal Plain. Thero was a long, level to nearly level fiat that lies adjacent to the site. The site was also part of the level to nearly level fiat. The wells were located in the yard, vegetated with fescue-type lawn grasses. Well # I was located closest to the street and ditch and Well # 2 was located further back.

The published Soil Survey of Isle of Wiqht County, Virginia, William F. Kitchel, et.ah, September 1986, shows the research site as being mapped as Yemassee fine sandy loam (23). Yemassee is a somewhat poorly drained soil.

A detailed soil profile description was made at the site and is included. When compared to the official soil series description for the Yemassee series (refer to the Appendix), the soil at this site falls within the range of characteristics. That means the soil was typical or representative of Yemassee soils.

Since the soil was unsuitable for a conventional gravity drainfield, a request had been made for permitting of some type of alternative system. A Puraflo (peat moss) Biofilter system was requested. Depth to wetness indicators was the major limitation.

CLIMATIC DATA FOR THE SITE:

The site was 1 mile from the home of an Environmental Health Specialist Senior (EHSS) who collected the precipitation data used for this study. ThiS current data was compared to the precipitation data published in the Soil Survey of Isle of Wi.qht County, Vir.qinia reference above. Precipitation data from the EHSS's home was used to evaluate rainfall during the study period. The precipitation comparison graph shows how each month's rainfall total compares to the monthly 30-year average (1951-1981).

It is apparent that 1999 was a very abnormal year. Hurricanes Dennis, Floyd and Irene produced rainfall totals in excess of 31 inches during a six week period from September 3 through October 18. For the January-June period, precipitation was slightly below normal with 1.72 inches short or 92%. For the July-December period, precipitation was dramatically above normal. In fact, rainfall was 182% of the long-term average for that period. Therefore, the water table levels at the'site would be expected to be shallower (nearer to the surface) than during a year with normal precipitation.

For the period January-June 2000, total precipitation was 3.45 inches below the 30-year average or 85%. That means that the water table levels would be expected to be slightly below normal at the site.

For the period July-December 2000, monthly rainfall was slightly below normal. Precipitation was 0.73 inches below the 30-year average or 97%. That means that the water table levels would be expected to be normal at the site.

For the period January-June 2001, total precipitation was 3.36 inches below the 30-year average or 85%. That means that the water table levels would be expected to be slightly below normal at the site.

Eleven of the thirty months (January, April, August, September and October 1999, January, April, July, August and September 2000, and June 2001) had precipitation levels above normal. For the entire study period of January 1999 through June 2001, overall precipitation was 11.85 inches above the 30-year average or 110%. Water table levels would be expected to be above normal at the site.

RESULTS:

Two automated data loggers were installed at the site on February 18,1999. Wells were installed in the same soil, same landscape position and at the same topographic elevation. Well # 1 was installed 50 feet back from the road ditch and Well # 2 was installed an additional 50,feet back from the ditch. The owner wants a permit for a Puraflo (peat moss) Biofilter system but it was believed the site was wetter than the conditions required for such a wastewater system. The owner believes the water table is being lowered by the ditch ("dry edge effect"). It was then decided to conduct a water table study to determine the actual conditions at the site. Due to operator error, Wells # 1 and # 2 were not programmed properly and the collection of water table data did not commence until March 14,1999. There was continuous data collection from the starting date until June 30, 2001 for Well # 1 and November 29, 2000 for Well # 2. Well # 2 stopped taking alarms for no apparent reason and did not function after November 29, 2000.

The Yemassee soil at this site had a brownish yellow matrix with yellowish red (5YR 5/6) and light gray (10YR 7/2) mottles (or iron depletions) in the top of the Bt horizon at 8 inches, making it a somewhat poorly drained soil. Btg horizons start at 12-18 inches with a Cg horizon at 42 inches. These soils normally have an apparent water table, which comes up from the bottom during precipitation events and goes down during dry periods'.

The water table hydrograph of March - June, 1999 shows the presence of free water in the soil within 6 inches for 1-2 days, 6-12 inches for 5~6 days, 12-18 inches for 12-18 days, 18-24 inches for 35-37 days, 24-30 inches for 44-64 days, 30-36 inches for 61-69 days, 36-40 inches for 75-78 days and dry for 31-34 days. Rainfall for this period was below average or 20.7 inches. Only April was above normal in precipitation while March, May and June were below normal.

The March - June, 1999 Groundwater Data Table shows that the surface of the free water for Well # 1 was in the Ap horizon 2 days or 2% of the time during this 109 day period, in the Bt horizon 5 days or 4% of the time, in the Btgl horizon 12-61 days or 11-55% of the time and the Btg2 horizon 78 days or 71% of the time. The Cg horizon was dry for 31 days or 28% of the time. For Well # 2, the surface of the free water was in the Ap horizon 1 day or 1% of the time during this 109 day period, in the Bt horizon 6-18 days or 6-17% of the time, in the Btgl horizon 37-69 days or 34-64% of the time and the Btg2 horizon 75 days or 69% of the time. The Cg horizon was dry for 34 days or 31% of the time.

The water table hydrograph of July - December, 1999 shows the presence of free water in the soil within 6 inches for 6-20 days, 6-12 inches for 14-26 days, 12-18 inches for 30-37 days, 18-24 inches for 76 days, 24-30 inches for 113-121 days, 30-36 inches for 127-130 days, 36-40 inches for 137-167 days and dry for 17-47 days. Rainfall for this period was greatly above average or 46.83 inches. August, September and October were above normal in precipitation while July, November and December were below normal.

The July - December, 1999 Groundwater Data Table shows that the surface of the free water for Well # 1 was in the Ap horizon 20 days or 11% of the time during this 184 day period, in the Bt horizon 26 days or 14% of the time, in the Btgl horizon 37-130 days or 20-70% of the time and the Btg2 horizon 167 days or 91% of the time. The Cg horizon was dry for 17 days or 9% of the time. For Well # 2, the surface of the free water was in the Ap horizon 6 days or 3% of the time during this 184 day period, in the Bt hodzon 14-30 days or 8-16% of the time, in the Btgl hodzon 76-127 days or 41-69% of the time and the Btg2 horizon 137 days or 74% of the time. The Cg horizon was dry for 47 days or 26% of the time.

The water table hydrograph of January - June, 2000 shows the presence of free water in the soil within 6 inches for 22-48 days, 6-12 inches for 46-72 days, 12-18 inches for 82-99 days, 18-24 inches for 119-124 days, 24-30 inches for 131-145 days, 30-36 inches for 141-164 days, 36-40 inches for 167-178 days and dry for · 4-15 days. Rainfall for this period was much below average or 18.97 'inches. January and April were above normal in precipitation while February, March, May and June were below normal.

The January - June, 2000 Groundwater Data Table shows that the surface of the free water for Well # 1 was in the Ap horizon 48 days or 26% of the time during this 182 day period, in the Bt horizon 72 days or 39% of the time, in the Btgl horizon 99-164 days or 54-90% of the time and the Btg2 horizon 178 days or 97% of the time. The Cg horizon was dry for 4 days or 2% of the time. For Well # 2, the surface of the free water was in the Ap horizon 22 days or 12% of the time during this 182 day period, in the Bt horizon 46-82 days or 25-46% of the time, in the Btgl horizon 119-141 days or 66-78% of the time and the Btg2 horizon 167 days or 92% of the time. The Cg horizon was dry for 15 days or 8% of the time.

The water table hydrograph of July - December, 2000 shows the presence of free water in the soil within 6 inches for 6-27 days, 6-12 inches for 13-36 days, 12-18 inches for 22-44 days, 18-24 inches for 43-64 days, 24-30 inches for 74-93 days, 30-36 inches for 88-117 days, 36-40 inches for 108-184 days and dry for 0-44 days. Rainfall for this period .was slightly below average or 24.99 inches. July, August and September were above normal in precipitation while October, November and December were below normal (October had no precipitation).

The July - December, 2000 Groundwater Data Table shows that the surface of the free water for Well # 1 was in the Ap horizon 27 days or 14% of the time during this 184 day period, in the Bt horizon 36 days or 19% of the time, in the Btgl horizon 44-117 days or 23-63% of the time and the Btg2 horizon 184 days or 100% of the time. The Cg horizon was never dry during this period. For Well # 2, the surface of the free water was in the Ap horizon 6 days or 4% of the time during this 152 day period, in the Bt horizon 13-22 days or 8-14% of the time, in the Btgl horizon 43-88 days or 28-58% of the time and the Btg2 horizon 108 days or 71% of the time. The Cg horizon was dry for 44 days or 29% of the time.

The water table hydrograph of January - June, 2001 shows the presence of free water in the soil within 6 inches for 21 days, 6-12 inches for 32 days, 12-18 inches for 45 days, 18-24 inches for 83 days, 24-30 inches for 117 daYs, 30-36 inches for 136 days, 36-40 inches for 172 days and dry for 9 days. Rainfall for this period was much below average or 19.06 inches. June was above normal in precipitation while January, February, March, Apdl and May were below normal.

The January - June, 2001 Groundwater Data Table shows that the surface of the free water for Well # 1 was in the Ap horizon 21 days or 12% of the time during this 181 day period, in the Bt horizon 32 days or 18% of the time, in the Btgl horizon 45-136 days or 25-75% of the time and the Btg2 horizon 172 days or 95% of the time. The Cg horizon was for 9 days or 5% of the time.

CONCLUSIONS:

This site had precipitation levels dramatically above normal for 10 months of the 28 months the study was conducted. Those ten months, April, August, September and October, 1999; January, April, July, August and September, 2000; and June, 2001; had totals of 81.43 inches, 36.64 inches above normal. That relates to 182% of normal precipitation for the ten months. The total study period (28 months) had 120.80 inches. Based on the 25-year average, this relates to 109% of normal precipitation.

Even with near normal precipitation, free water was present for significant periods of time during the study period. In addition, the depth to free water was much shallower than where gray mottles were found in the soil. Once the table rose in the soil, it remained for an extended period of time.

Free water was observed in the Ap horizon for fairly long periods of time and was always associated with precipitous rises in the water table. For the entire study period, free water was in this horizon for 35 to 118 days of the total 840 days or 6 to 14 percent of the time, though not continuously. There were no soil morphological features that could be related to the presence of water in the soil for the number of days observed.

Free water was observed in the Bt horizon for 150 to 171 days of the total 840 days during the entire study period and was always associated with sharp rises in the water table. This relates to 20 to 24 percent of the time. Yellowish red (5YR 5/6) and light gray (10YR 7/2) mottles were soil morphological features that could be related to the presence of water in the soil for the number of days observed.

Free water was observed in the Btgl horizon for 415 to 608 days of the total 840 days during the entire study period and was always associated with sharp rises in the water table. This relates to 66 to 72 percent of the time. Light brownish gray (10YR 6/2), brownish yellow (10YR 6~6) and yellowish red (5YR 5/6) mottles in a mottled hodzon were soil morphological features that could be related to the presence of water in the soil for the number of days observed.

Free water was observed in the Btg2 horizon for 487 to 779 days of the total 840 days during the entire study period and was always associated with sharp rises in the water table. This relates to 78 to 93 percent of the time. Light brownish gray (10YR 6~2), brownish yellow (10YR 6~6) and yellowish red (5YR 5/6) mottles in a mottled horizon were soil morphological features that could be related to the presence of water in the soil for the number of days observed.

The presence of yellowish red (5YR 5/6) and light gray (10YR 7/2) redoximorphic features (mottles) were soil morphologic features that could be related to the presence of water in the soil for extended periods of time. During the winter-spring time of the year, the seasonal water table was present in the Bt horizon for 1/5 of the ti me.

It must be remembered that when the surface of the water table was in one of the upper horizons such as the Bt, the Btgl and lower horizonS were saturated. Free water was observed in the Btgl horizon for 1/3 to 3/4 of the time and 7/10 to 8/10 of the time in the Btg2 horizon. These horizons had light brownish gray (10YR 6/2), brownish yellow (10YR 6/6) and yellowish red (5YR 5~6) redoximorphic features (mottles) in a mottled horizon.

Redoximorphic features (mottles) in the Cg horizon were exhibited as brownish yellow (10YR 6/6~) mottles in a gleyed matrix. Since this was the lowest horizon in the profile and gleyed, the seasonal water table would be expected to have a longer duration than the upper horizons.

As was noted earlier, this soil exceeded the minimum state requirements for a conventional gravity drainfleld based on soil morphology. Based on the period studied, it is apparent that if a conventional septic system had been installed, the gravel filled trenches (at a depth of 18 inches) would have been inundated with free water for extended periods of time. Based on the state sewage regulations in effect when the application was submitted, a 6-inch zone of suitable soil beneath the gravel filled trenches would have been required (the "stand-off zone") for treatment and disposal of the wastewater. Based on this research, the seasonal water table would have been in the "stand-off zone" at least 51% to 54% of the time during a winter-spring period. Although soil morphology indicated this soil was unsuitable for a conventional gravity drainfield, the monitoring data taken while there was slightly above normal precipitation showed the soil was unsuitable.

The owner requested that a permit be issued for some type of alternative Wastewater system. Free water was observed in the Bt horizon for 52 to 109 days or 18% to 23% of the time during a winter-spring period. It should also be pointed out that precipitation during this study was above normal. An alternative wastewater system needing only a 12-inch separation below the soil surface might be considered.

Yemassee fine sandy loam

Profile for Well # 1: (WL40)

Ap--0 to 8 inches, dark grayish brown (10YR 4/2) fine sandy loam; weak coarse granular structure; very friable, nonsticky, nonplastic.

Btm8 to 12 inches, brownish yellow (10YR ~6/6) sandy clay loam; many medium and coarse prominent yellowish red (5YR 5/6) and light gray (10YR 7/2) mottles; weak medium subangular blocky structure; friable, slightly sticky, slightly plastic.

Btg'l-12 to 36 inches, mottled light brownish gray (10YR 6/2), brownish yellow (10YR 6/6) and yellowish red (5YR 5/6) sandy clay loam; weak medium subangular blocky structure; friable, slightly sticky, slightly plastic.

Btg2-36 to 42 inches, mottled light brownish gray (10YR 6/2), brownish yellow (10YR 6/6) and yellowish red (5YR 5/6) sandy loam; weak coarse subangular blocky structure; friable, slightly sticky, nonplastic.

Cg--42 to 48 inches, light gray (10YR 7/2) loamy sand; many medium and coarse distinct brownish yellow (10YR 6/6) mottles; massive; single grain structure; loose.

Remarks: This profile taken from an auger hole.

Profile for Well # 2: (WL40)

Ap--0 to 8 inches, dark grayish brown (10YR 4/2) fine sandy loam; weak coarse granular structure; very friable, nonsticky, nonplastic.

Bt--8 to 18 inches, brownish yellow (10YR 6~6) sandy clay loam; many medium and coarse prominent yellowish red (5YR 5/6) and light gray (10YR 7/2) mottles; weak medium subangular blocky structure; friable, slightly sticky, slightly plastic.

Btg1-18 to 36 inches, mottled light brownish gray (10YR 6/2), brownish yellow (10YR 6/6) and yellowish red (5YR 5/6) sandy clay loam; weak medium subangular blocky structure; friable, slightly sticky, slightly plastic.

Btg2-36 to 42 inches, mottled light brownish gray (10YR 6~2), brownish yellow (10YR 6/6) and yellowish red (5YR 5/6) sandy loam; weak coarse subangular blocky structure; friable, slightly sticky, nonplastic.

Cg--42 to 48 inches, light gray (10YR 7~2) loamy sand; many medium and coarse distinct brownish yellow (10YR 6/6) mottles; massive; single grain structure; loose.

Remarks: This profile taken from an auger hole.

Table I - - Yemassee fine sandy loam Groundwater Data Table
March-June, 1999 (109 Days)

	Well # 1				Well #2			
			Percent				Percent	
Depth Range (in.)	Number of Days	Percent Time	Cumulative Days	Cumulative Days	Number of Days	Percent Time	Cumulative Days	Cumulative Days
0-6	2	2	2	2	1	I	1	1
6.1-12	3	3	5	4	5	5	6	6
12.1-18	7	6	12	11	12	11	18	17
18.1-24	23	21	35	31	19	17	37	34
24.1-30	9	8	44	39	27	25	64	60
30.1-36	17	16	61	55	5	5	69	64
36.1-40	17	16	78	71	6	5	75	69
Dry	31	28	109	100	34	31	109	100

Table 2 - - Yemassee fine sandy loam Groundwater Data Table
July-December, 1999 (184 Days)

	Well # 1				Well #2			
			Percent				Percent	
Depth Range (in.)	Number of Days	Percent Time	Cumulative Days	Cumulative Days	Number of Days	Percent Time	Cumulative Days	Cumulative Days
0-6	20	11	20	11	6	3	6	3
6.1-12	6	3	26	14	8	5	14	8
12.1-18	11	6	37	20	16	9	30	16
18.1-24	39	21	76	41	46	25	76	41
24.1-30	45	25	121	65	37	20	113	61
30.1-36	9	5	130	70	14	7	127	69
36.1-40	37	20	167	91	10	5	137	74
Dry	17	9	184	100	47	26	184	100

Number of Days column refers to the number of days the surface of the free water was present within the depth range.

Percentage of Time column refers to the percent of time the water was present within the depth range.

Cumulative Days column refers to the total number of days the water was present within the depth range.

Percentage of Cumulative Days refers to the percent of total time the water was present within the depth range.

DRY corresponds to the number of readings (converted to days) where the. monitoring well recorded no water in the hole.

Days in the column headings corresponds to the number of data logger readings within a depth range divided by the number (normally 2, 4 or 8) of data logger readings per day.

Table 3 - - Yemassee fine sandy loam Groundwater Data Table
January-June, 2000 (182 Days)

		Well # 1				Well # 2		
Depth Range (in.)	Number of Days	Percent Time	Pement Cumulative Days	Cumulative Days	Number of Days	Percent Percent Time	Cumulative Days	Cumula~ve Days
0-6	48	26	48	26	22	12	22	12
6.1-12	24	13	72	39	24	13	46	25
12.1-18	27	15	99	.54	36	20	82	46
18.1-24	25	14	124	67	37	20	119	66
24.1-30	21	12	145	79	12	7	131	72
30.1-36	19	11	164	90	10	6	141	78
36.1-40	14	7	178	97	26	14	167	92
Dry	4	2	182	100	15	8	182'	100

Table 4 - - Yemassee fine sandy loam Groundwater Data Table
July-December, 2000 (184 Days)

		Well # 1				Well # 2		
Depth Range (in.)	Number of Days	Percent Time	Percent Cumulative Days	Cumulative Days	Number of Days	Percent Percent 'Time	Cumulative Days	Cumulative Days
0 - 6	27	14	27	14	6	4	6	4
6.1-12	9	5	36	19	7	4	13	8
12.1-18	8	4	44	23	9	6	22	14
18.1-24	20	11	64	34	21	14	43	28
24.1-30	29	16	93	50	31	21	74	48
30.1-36	24	13	117	63	14	9	88	58
36.1-40	67	37	184	100	20	13	108	71
Dry	.....				44	29	152	100

Number of Days column refers to the number of days the surface'of the free water was present within the depth range.

Percentage of Time column refers to the percent of time the water was present within the depth range.

Cumulative Days column refers to the total number of days the water was present within the depth range.

Percentage of Cumulative Days refers to the percent of total time the water was present within the depth range.

DRY corresponds to the number of readings (converted to days) where the monitoring .well recorded no water in the hole.

Days in the column headings corresponds to the number of data logger readings within a depth range divided by the number (normally 2, 4 or 8) of data logger readings per day.

Table 5 - - Yemassee fine sandy loam Groundwater Data Table
January-June, 2001 (181 Days)

	Well # 1				Well # 2			
Depth Range (in.)	Number of Days	Percent Time	Percent Cumulative Days	Cumulative Days	Number of Days	Percent Time	Percent Cumulative Days	Cumulative Days
0-6	21	12	21	12				
6.1-12	11	6	32	18				
12.1-18	13	7	45	25				
18.1-24	38	21	83	46				
24.1-30	34	19	117	.65				
30.1-36	19	10	136	75				
.36.1-40	36	20	172	95				
Dry	9	5	181	100				

Number of Days column refers to the number of days the surface of the free water was present within the depth range.
Percentage of Time column refers to the percent of time the water was present within the depth range.
Cumulative Days column refers to the total number of days the water was present within the depth range.
Percentage of Cumulative Days refers to the percent of total time the water was present within the depth range.
DRY corresponds to the number of readings (converted to days) where the monitoring well recorded no water in the hole.
Days in the column headings corresponds to the number of data logger readings within a depth range divided by the number (normally 2, 4 or 8) of data logger readings per day.

Isle of Wight County
Yemassee Fine Sandy Loam
Scale: 1"= 30'

Road

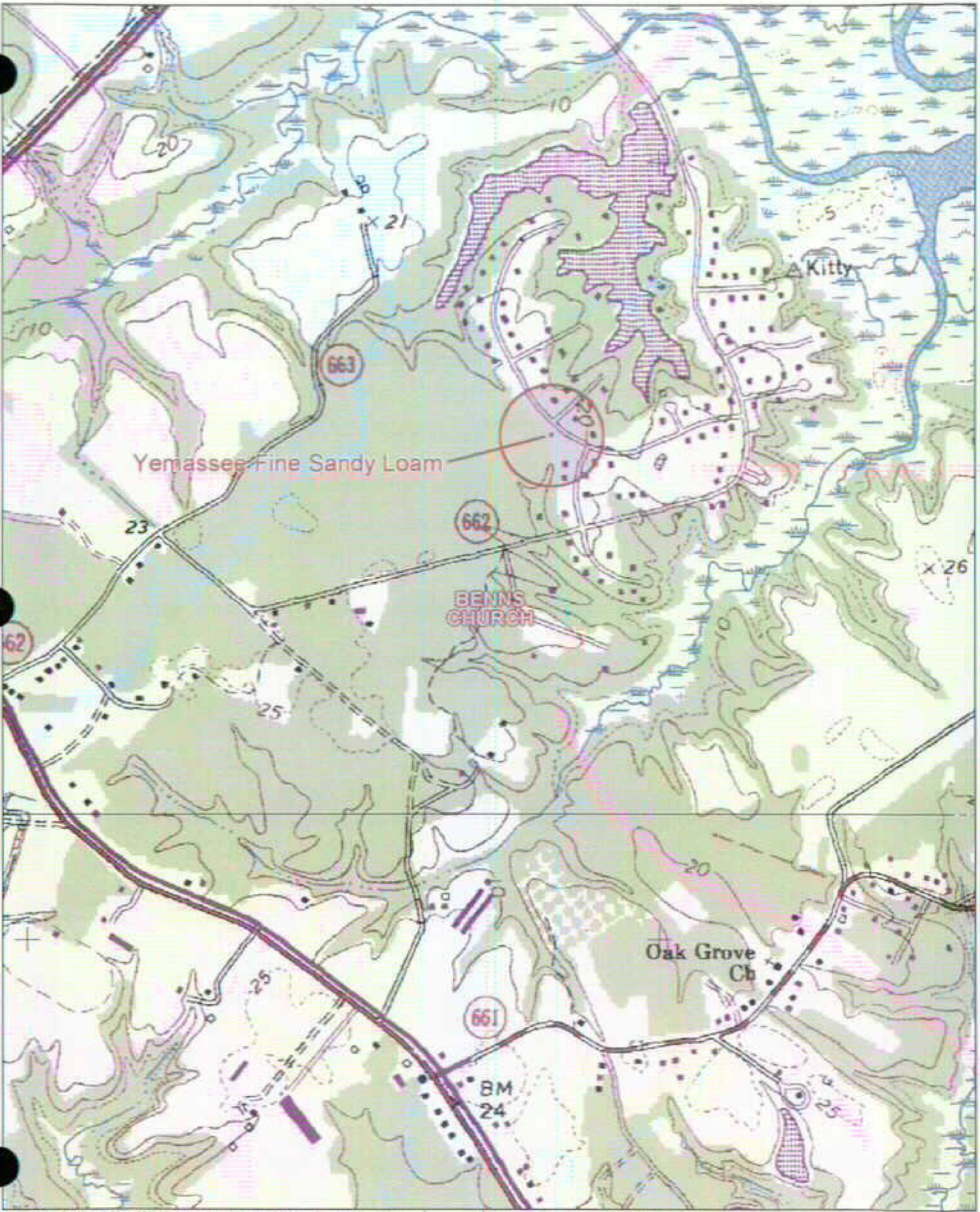
Property corner
stake~--7---~ ~ Ditch

50'

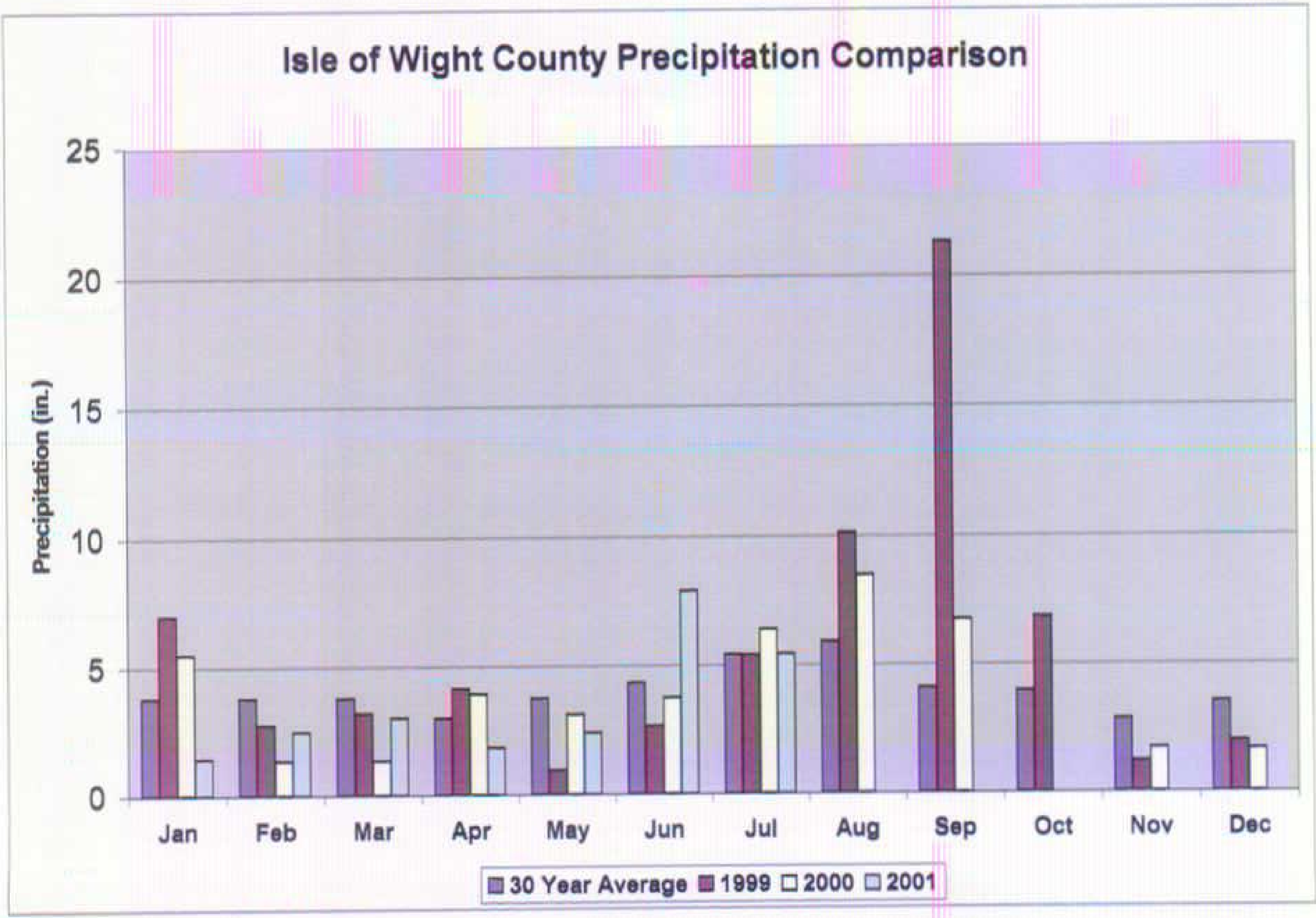
Data Logger #1
WL-40

50'

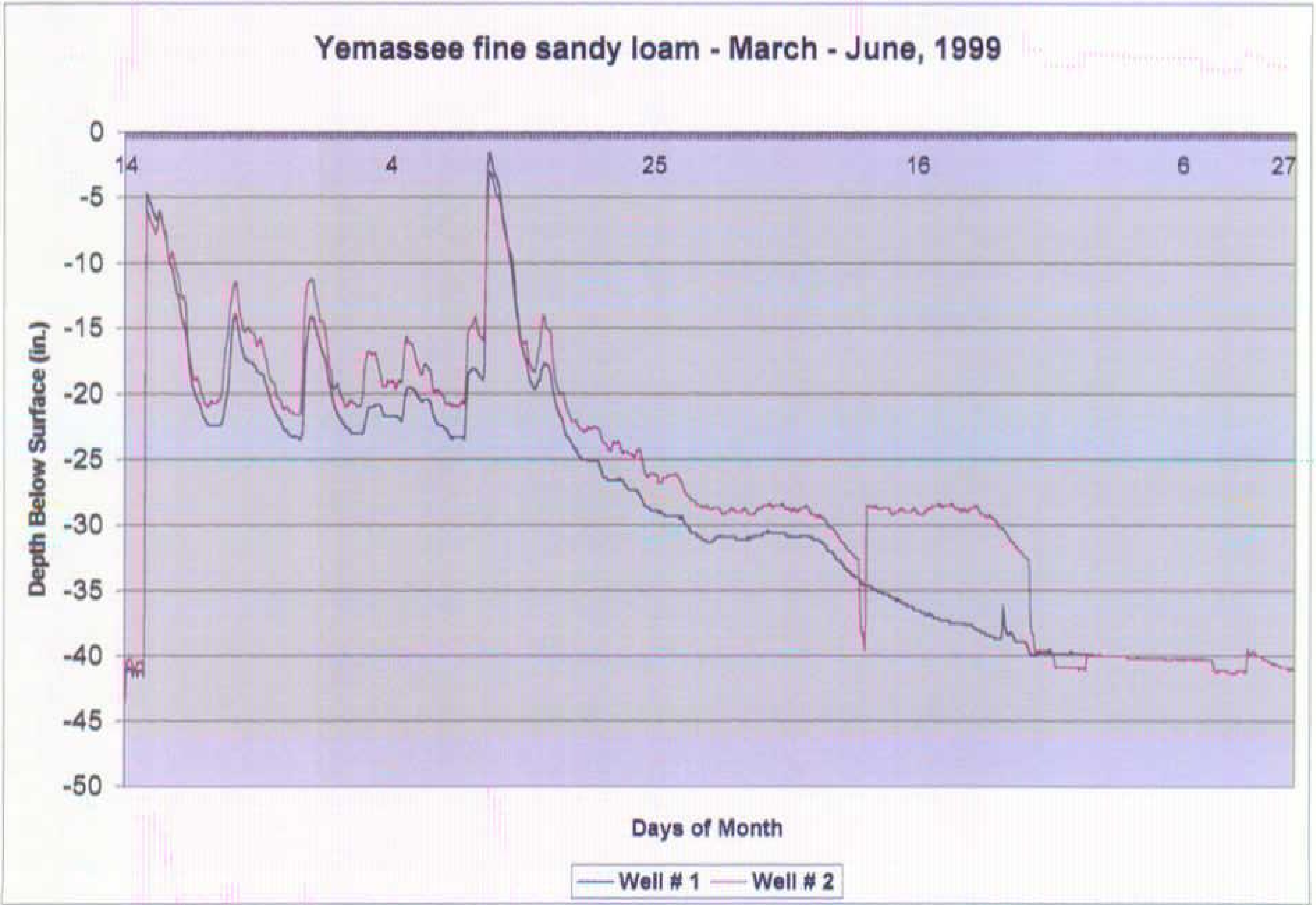
Data Logger #2
WL-40



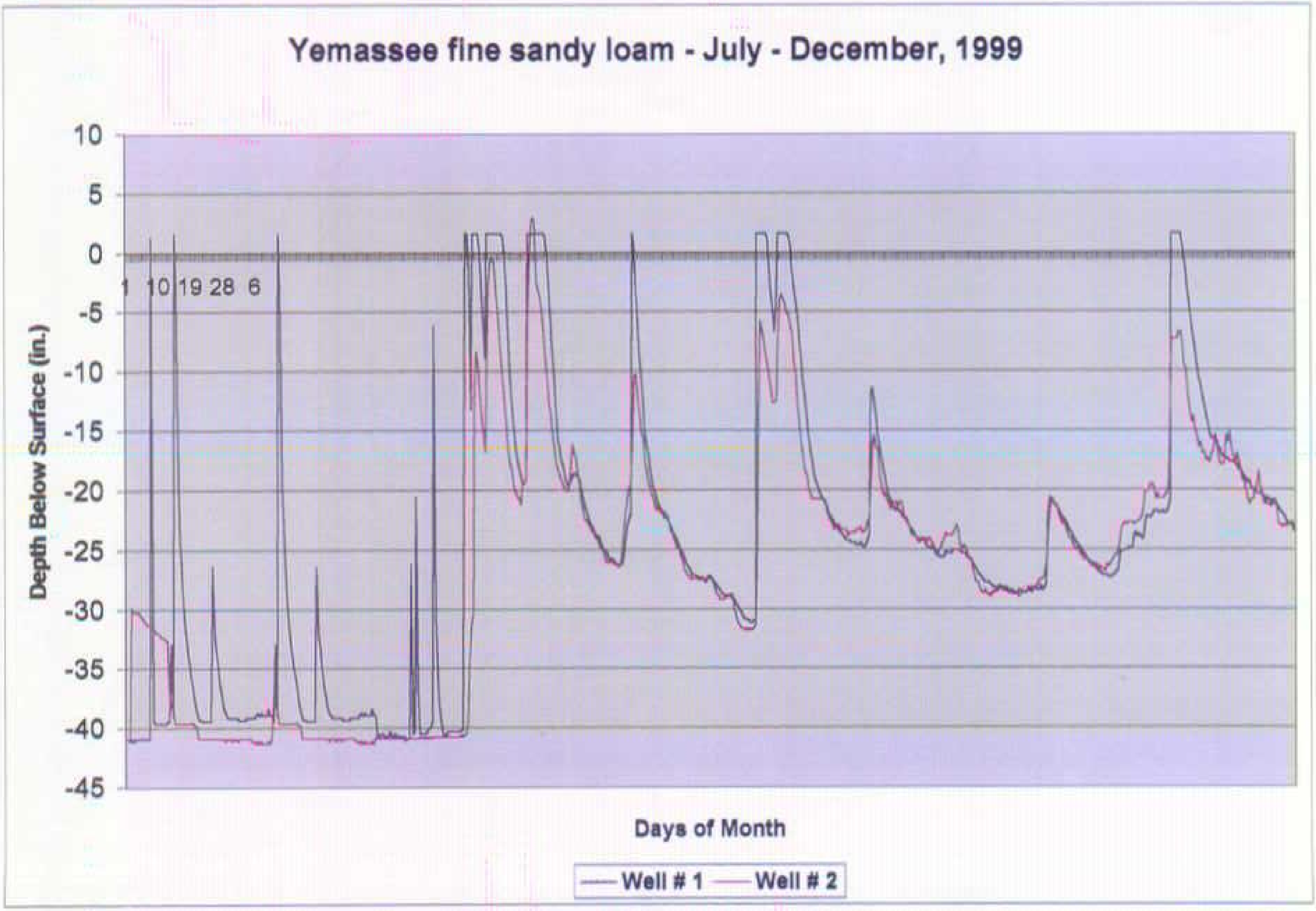
 450 ft Scale: 1 : 12,000 Detail: 14-0 Datum: WGS84



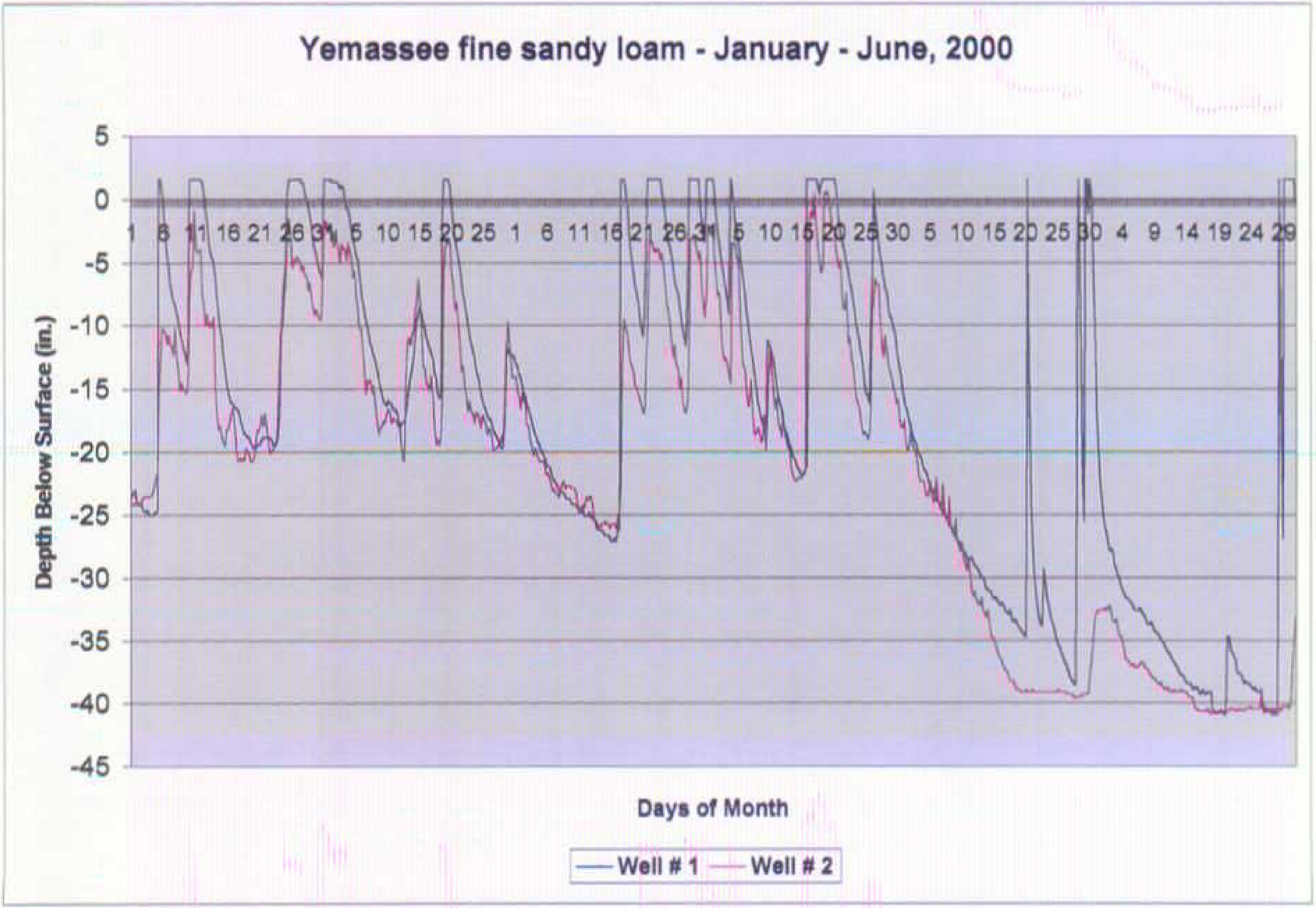
Isle of Wight County Precipitation Comparison
Precipitation (in.)
25
20
15
10
5
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
30 Year Average
1999
2000
2001



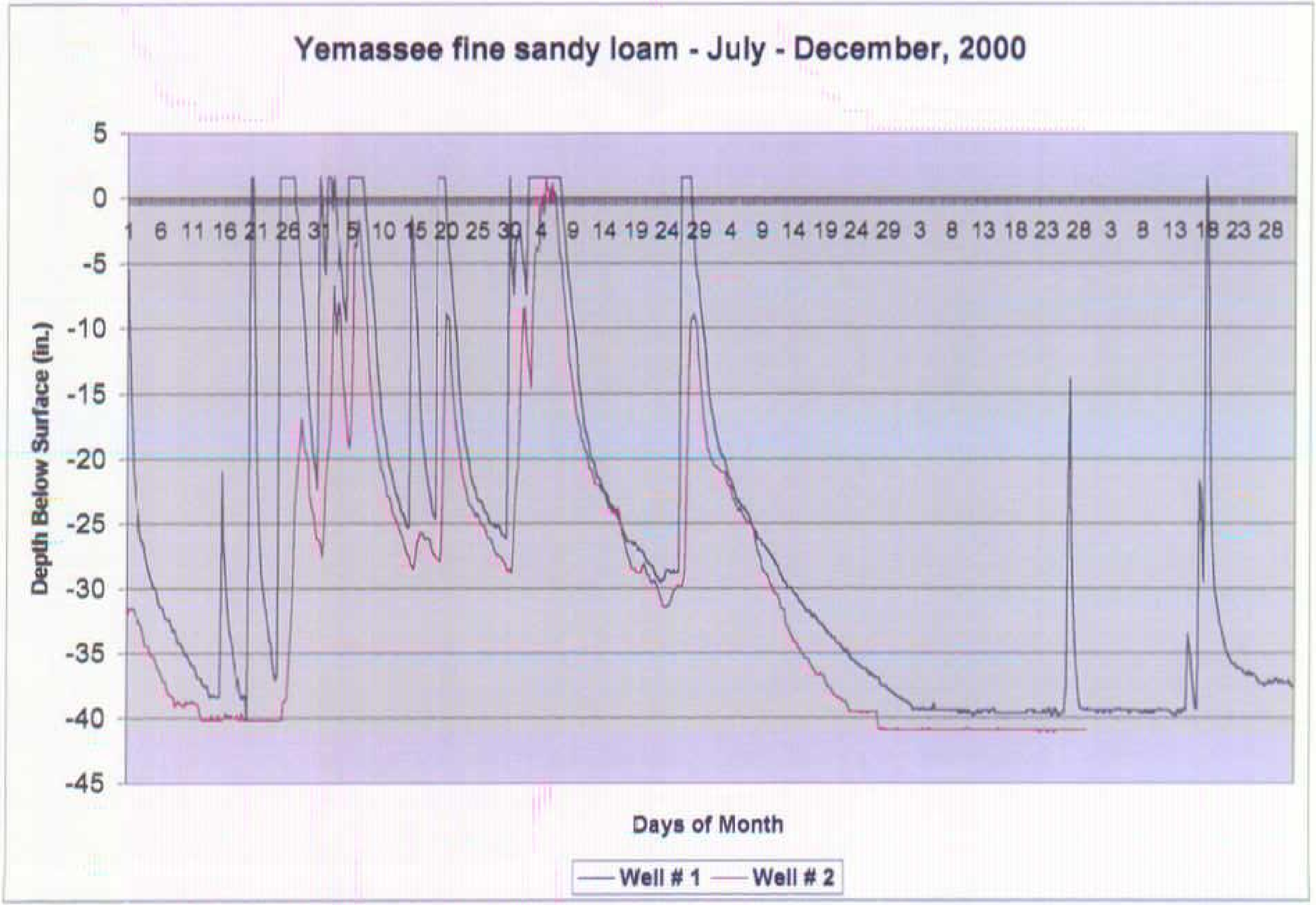
Yemassee fine sandy loam - March - June, 1999
Depth Below Surface (in.)
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
14
4
25
16
6
27
Days of Month
Well # 1
Well # 2



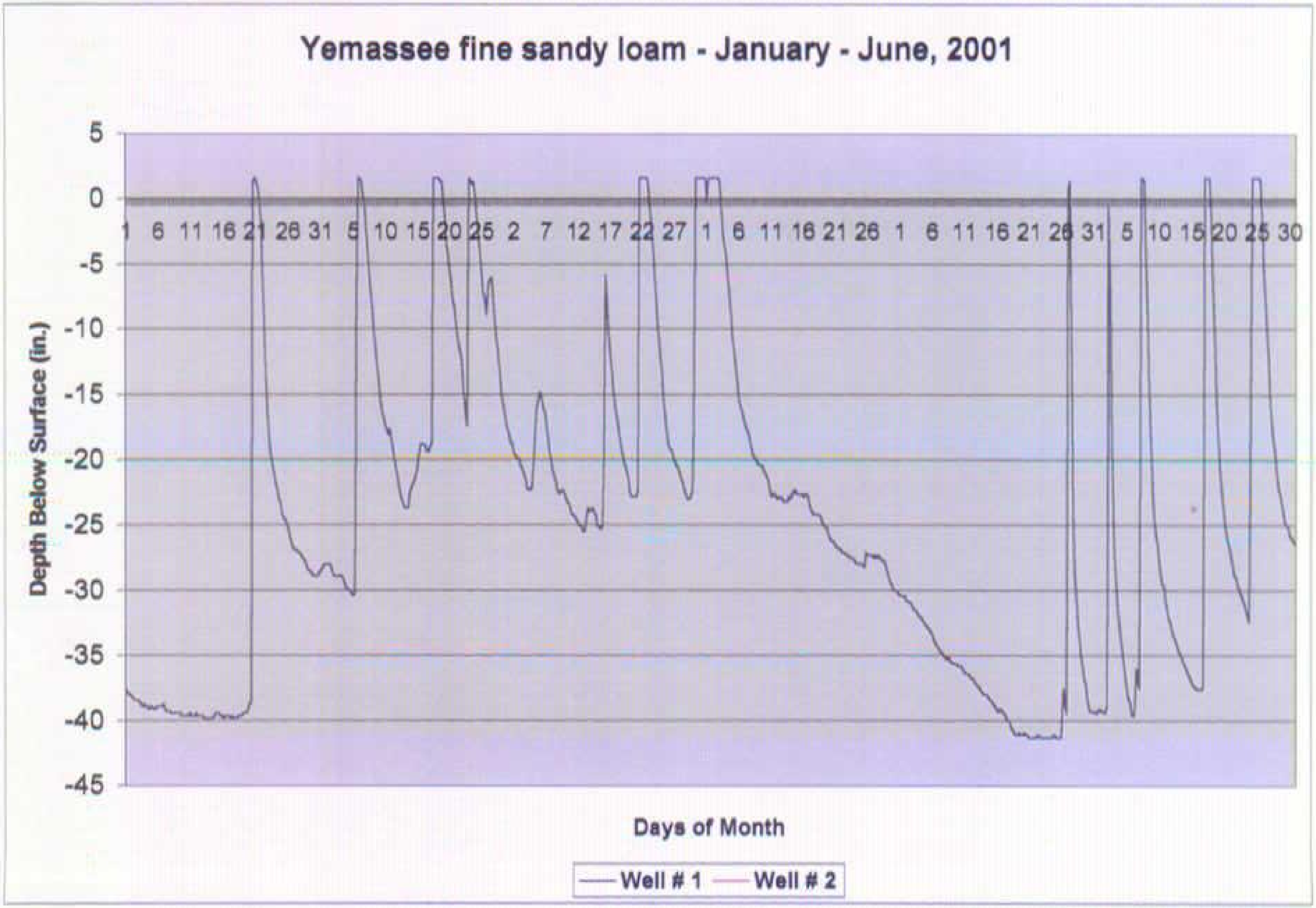
Yemassee fine sandy loam - July - December, 1999
10
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
Depth Below Surface (in.)
1 10 19 28 6
Days of Month
Well # 1
Well # 2



Yemassee fine sandy loam - January - June, 2000
Depth Below Surface (in.)
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
Days of Month
Well # 1
Well # 2



Yemassee fine sandy loam - July - December, 2000
Depth Below Surface (in.)
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
1 6 11 16 21 26 31 5 10 15 20 25 30 4 9 14 19 24 29 4 9 14 19 24 29 3 8 13 18 23 28 3 8 13 18 23 28
Days of Month
Well # 1
Well # 2



Yemassee fine sandy loam - January - June, 2001
Depth Below Surface (in.)
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
1 6 11 16 21 26 31 5 10 15 20 25 2 7 12 17 22 27 1 6 11 16 21 26 1 6 11 16 21 26 31 5 10 15 20 25 30
Days of Month
Well # 1
Well # 2

SOIL EVALUATED: Zoar silt loam

LOCATION:

This research site was located in the northern portion of Montgomery County, Virginia. Refer to the accompanying portion of the U.S. Geologic Survey Radford North topographic map for the general character of the area. The topographic portion also indicates the general location of the WL-40 data logger.

RATIONALE FOR SITE SELECTION:

There were several reasons for using this site. First, I have limited data from a previous water table study completed years earlier that would be verified with additional data. Second, there were shallow horizons present that were thought to be restrictive to downward water movement that would show up better with a study period. Also as part of the second idea, I was trying to determine at this site, was the water table perched, did it rise from lower depths or were both suggestions correct? Finally, the soil had a high amount of manganese present in the profile and manganese is often used as a wetness indicator.

SOIL AND SITE INFORMATION:

The soil at this site formed from alluvial sediments of the New River. There was a short, moderately steep hillside lOOyards upslopeof the site. The site was on a small section of a river terrace tread with slopes of 1-2 % The WL-40 well was installed in a fescue grass area in a buffer area between a corn field and the steep sideslope below the terrace landscape.

The site was evaluated as part of a special study. The participants of the study classified the soil at this site as Zoar silt loam. Zoar has a perched water table that is moderately deep. The Zoar series is considered to be a moderately well drained soil.

A detailed soil profile description was made at the site and is included. Dr. William Edmonds and Dr. Pamela Thomas of the Crop and Soil Environmental Sciences Department of Virginia Tech wrote the profile description. When compared to the official soil series description for the Zoar series (refer to the Appendix), the soil at this site falls within the range of characteristics. That means the soil was typical or representative of Zoar soils.

This site was not suitable for conventional onsite systems as approved by the Virginia Department of Health. If it were not for the nearby stream, spray irrigation would be a consideration as a solution to the high water table problem at this site.

CLIMATIC DATA FOR THE SITE:

The site was less than 1 mile from the Kentland weather station, where official NOAA weather data are collected, so precipitation data from the station was used to evaluate rainfall during the study period. The precipitation comparison graph shows how rainfall totals each month compares to the monthly 25-year average (1965-1990).

It is apparent that for the November-December 1999 period, precipitation was below normal with only three months having near or exceeding the 25-year average. That precipitation level means the water table levels might be lower than expected under normal conditions. Storms in July and September delivered almost 5-inches more rain than normal during those two months. The last three months of 1999 were dry and water tables would be expected to be lower in the soil profile.

For the period January-June 2000, total precipitation was only 2.0 inches below the 25-year average. That means the water table levels would be expected to be slightly lower but still representative of normal conditions at the site.

For the period July-December 2000, monthly rainfall was generally below normal by 5.0 inches. It is noteworthy that only 0.01 inches of rain was recorded for the entire month of October 2000, making it the driest October since data collection began in southwest Virginia. The October-December 2000 period was extremely dry. In fact, rainfall was only 49% of the long-term average for that 3 month span. That dry fall situation was very similar to moisture conditions noted for November-December 1999. Therefore, the water table levels at the site would be expected to be definitely lower than during a fall with normal precipitation. For the pedod January-June 2001, monthly rainfall was generally below normal. Therefore, the water table levels at the site would be expected to be shallower during a winter and spring with normal precipitation.

Except for a feTM exceptional wet mOnths (April and June of 2000), the overall precipitation situation was one of below normal to near drought conditions. It should be noted that the original project completion date was extended due to severe drought conditions in most of the state during 1999. The entire year 2000 was also well below normal precipitation levels. Southwest Virginia is in the fourth straight year with below normal precipitation. As of November 24, 2001, the area is 13 inches below normal precipitation levels.

RESULTS:

An automated WL-40 data logger was installed January 27, 2000 on the terrace tread. The well was representative of the soil conditions at the site. Due to a programming error, the automated well was not programmed properly and the collection of water table data did not commence until February 2000. There was continuous data collection from the starting date until April 3, 2001.

The Zoar soil at this site had common light gray (10YR 7~2) mottles (or iron depletions) below 23 inches in the Btcl horizon, making it.a moderately well drained soil. Normally, it would be assumed that the seasonal water table would be below 23 inches, while there might be brief periods where it was above that depth. These soils normally have a perched water table. The dense, brownish yellow, pale brown and light gray mottled Btc2 and Btc3 horizons were restrictive.

The January-June 2000 hydrograph shows the water table graphed as a straight line until the end of March at the 43. l-inch level. The data logger then dropped to 46.3 and remained at that level except for a spike in May and in June. There was no drop in the graph line starting in early May, which corresponds to spring plant growth and the rapid increase in evapotranspiration. The data logger remained dry for all of the pedod, except for the two spikes of rapid water table rise and fall.

The January-June 2000 Groundwater Data Table showed that free water was in the Btcl horizon about 1 day or 1% of the time during this 141day period. Free water was only briefly in the Btc horizons for less than one day during the entire period. Possible free water was in the Btc3 horizon 62 days, or 43% of the time. The data logger recorded a water level between 41.4 and 46.3 inches for 78 days or 55% of the time.

The seasonal water table was much deeper than the depth to gray mottles at least 40% to 98% of the time for this monitoring period. The reality was that the water table simply did not exist. Two-percent levels are given above because all the readings were within an extremely narrow band. The first half of the period, the band was the 41.1 level and the last half of the period the band was the 46.3 level. The data is unreliable; water tables are not static, the levels move up and down; never in a straight line for long periods of time. No positive water table readings were present because of the prolonged drought.

The July-December 2000 hydrograph shows nearly continuous dry hole readings, from July thru December and even into April 2001. For the July-December period with the exception of a two-tenths inch spike, all readings were between 45.8 - 46.5 inches. During the January-April, 2001 period, the readings were on the 46.1-inch level. All of the readings are straight lines, atypical of water table graphs.

The graphs help explain the graphs of the shallow well also at this site. With no lines in the 22-24 inch range on this graph (such that existed on the WL-20 well) it farther substantiates the shallow well graphs as incorrect or false. Again no positive readings were recorded because of the drought. Information contained in the Groundwater Data Tables is somewhat misleading. Trying to explain the numerous reading points all occurring within a very narrow band is difficult. This WL-40 data logger recorded data at 46 inches yet the design of the unit indicates sampling accuracy to 40-inches.

CONCLUSIONS:

This site had precipitation levels well below normal for the majority of the study period. There was no free water present for significant periods of time during the winter and spring. In addition, the depth to free water was much deeper than the data loggers were able to record. The water table essentially did not exist at an observable depth during the study.

There were no soil morphologic features that could be related to the presence of water in the soil profile for the number of days observed. Free water was observed in the Btc horizons for extended periods of time. All of the soil clues suggest a much higher water table. The clues are in reverse of what should have occurred in the data loggers wells. The dry years before and during the study did not have the water to form a water table.

To really understand how dry the soil was, the data logger recorded only three small spikes in 15 months. The presence of mottles and the concretions in the Btc horizons suggest the presence of the seasonal water table for extended periods of time. During the normally wetter winter months in the earlier study, the seasonal water table was present in the Btc horizons.

It can only be expected that under normal to increased precipitation levels, the seasonal water table may return to their previous levels. Considering that thought, individuals making soils evaluatio,ns need to focus closely in on the soil morphology clues indicating wetness or water table problems. The clues are preserved in the soil and do not change frequently due to drought or flood phenomena. Even the winter months during a drought will have severely depressed water table levels. No definitive statements may be made concerning water table levels when the
water table does not exist.

With the deeper WL-40 well installed a few feet away from the WL-20 well, the meaning of the many readings between 20 and 21 inches may help explain the problem. There were no readings in the WL-40 data logger at the 20 to 21-inch level. Two answers are possible for the anomaly. First, the auger hole for the deeper well allowed water to flow down through the restrictive horizons to lower depths and water never actually perched. Second, the precipitation levels were so Iow that water tables never developed at any of the depths being recorded by the data logger.

A manual well should be included as part of the study apparatus at each site. Once each month during the November through April period, during a site visit to collect data, an auger boring should be made to check for free water in the soil. Soil scientists need to observed and be able to correlate the actual soil moisture level to the data logger reading level.

The capacitance sensor is pictured as resting on a round disk in the base of the data logger. In the wells involved in my study, none of those disks were in place. Would those disks prevent the echoing or numerous readings recorded at the end and beyond the capability of the unit? This well recorded data to the 46-inch range yet the data logger only samples to 40 inches by design.

Zoar silt loam

Profile for Well # 1: (VVL20)

Ap--0 to 10 inches; dark grayish brown (10YR 4/2), broken, silt loam; moderate medium granular structure; friable, non-sticky, non-plastic; many fine and medium roots; many fine and very fine tubular and vesicular pores; moderately acid; abrupt wavy boundary.

BA--10 to 23 inches; yellowish brown (10YR 5/4), broken, loam; weak medium subangular blocky structure; friable, slightly sticky, slightly plastic; common very fine and fine roots; common fine and very fine tubular and vesicular pores; strongly acid; gradual wavy boundary.

Btcl--23 to 32 inches; yellowish brown (10YR 5/8), broken, sandy clay loam; many medium distinct brownish yellow (10YR 6/4), broken, and light gray (10YR 6/1), broken, iron and manganese redox depletions; moderate medium subangular blocky structure; firm, slightly sticky, slightly plastic; common very fine and fine roots; few medium vesicular pores; few distinct brown (10YR 5/3), broken, clay films on faces of peds and in pores; common medium irregular black (10YR 2/1), broken, manganese and iron nodules and masses with diffuse boundaries; moderately acid; diffuse smooth boundary.

Bt¢2--32 to 47 inches; yellowish brown (10YR 6/8) broken, clay loam; many medium distinct pale brown (10YR 6/3), broken, and light gray (N 7/0), broken, iron and manganse redox depletions; moderate medium and fine subangular blocky structure; firm, slightly sticky, slightly plastic; few very fine roots; few fine and medium vesicular pores; many distinct brown (10YR 5/4), broken, clay films on faces of peds and in pores; many medium rounded black (10YR 2/1), broken, manganese and iron nodules and masses with diffuse boundaries; moderately acid; diffuse smooth boundary.

Btc3-- 47 to 68 inches; yellowish brown (10YR 5/8) broken, loam; many medium distinct pale brown (10YR 6/3), broken, and light gray (10YR 6/1), broken, iron and manganese redox depletions; weak coarse platy structure; firm, slightly sticky, slightly plastic; few very fine roots; few fine and medium vesicular pores; many prominent brown (10YR 5/3), broken, clay films on faces of peds and in pores; common medium irregular black (10YR 2/1), broken, iron and manganese nodules and masses with diffuse boundaries; strongly acid; clear smooth boundary.

2Btc4-68 to 76 inches; yellowish brown (10YR 5/4), broken, gravelly sandy clay loam; many medium distinct pale brown (10YR 6/3), broken, iron and manganese redox depletions; weak medium platy structure; friable, slightly sticky, slightly plastic; few very fine roots; common fine and medium vesicular pores; many prominent yellowish brown (10YR 5/4), broken, clay films on faces of peds and in pores; many medium irregular very dark gray (N 3/0), broken, and black (10YR 2/1), broken, iron and manganese nodules and masses with diffuse boundaries; 20 percent rounded quartz gravels and 5 percent rounded quartz cobbles; very strongly acid; clear smooth boundary.

3Bt-76 to 91inches; strong brown (7.5YR 5/6), broken, sandy clay loam; weak medium platy structure; friable, slightly sticky, slightly plastic; few very fine roots; few medium vesicular pores; common prominent brown (10YR 5/3), broken, clay films on faces of peds and in pores; few medium irregular black (10YR 2/1), broken, iron and manganese nodules and masses with diffuse boundaries; 2 percent rounded quartz, angular chert, and irregular shale gravels; very strongly acid.

Remarks: This profile description taken from an excavated pit by Dr. William Edmonds and Dr. Pamela Thomas ofVPI & SU Crop and Soil Environmental Sciences Department during August 1992. The pit was excavated in a fescue grass field.

Table I - - Zoar silt loam Groundwater Data Table
January - June, 2000 (141 Days)
Kentland, Data Logger Well # 1

Well # 1

Depth Range (in.)	Number of Days	Pement Time	Cumulative Days	Percent Cumulative Days
0-6	0	0	0	'0
6.1-12	0	0	0	0
12.1-18	0	0	0	0
18,1-24	1	1	1	1
24,1-30	1	1	I	1
3O, 1-36	1	1	2	1
36.1-41.4	61	43	63	41
41.4 -46.3(Dry)	78	54	141	100

Table 2 - - Zoar silt loam Groundwater Data Table
July - December, 2000 (184 Days)
Kentland, Data Logger Well # 1

Well # 1

Depth Range (in.)	Number of Days	Percent Time	Cumulative Days	Percent Cumulative Days
0-6	0	0	0	0
6.1-12	0	0	0	0
12.1-18	0	0	0	0
18.1-24	0	0	0	0
24.1-30	0	0	0	0
30.1-36	0	0	0	0
36.1-45.5	0	0	0	0
45.6-46.1	49	26	49	26
46.15-46.6	135	73	184	100

Number of Days column refers to the number of days the surface of the free water was present within the depth range.
Percentage of Time column refers to the percent of time the water was present within the depth range.
~Cumulative Days column refers to the total number of days the water was present within the depth range.
' Percentage of Cumulative Days refers to the percent of total time the water was present within

the depth range.
DRY corresponds to the number of readings (converted to days) where the monitoring well recorded no water in the hole. '
Days in the column headings corresponds to the number of data logger readings within a depth range divided by the number (normally 2, 4 or 8) of data logger readings per day.

Table I - - Zoar silt loam Groundwater Data Table
January - April, 2001 (93 Days)
Kentland, Data Logger Well # t

Well # 1

Depth Range (in.)	Number Of Days	Percent Time	Cumulative Days	Percent Cumulative Days
0-6	0	0	0	0
6.1-12	0	0	0	0
12.1-18	0	0	0	0
18.1-24	0	0	0	0
24.1-30	0	0	1	1
30.1-36	1	1	1	1
36.1-42	1	1	2	2
42.1.46(Dry)	12	13	14	, 15
46.1-46.4(Dry)	79	84	92	100

Number of Days column refers to the number of days the surface of the free water was present within the depth range.

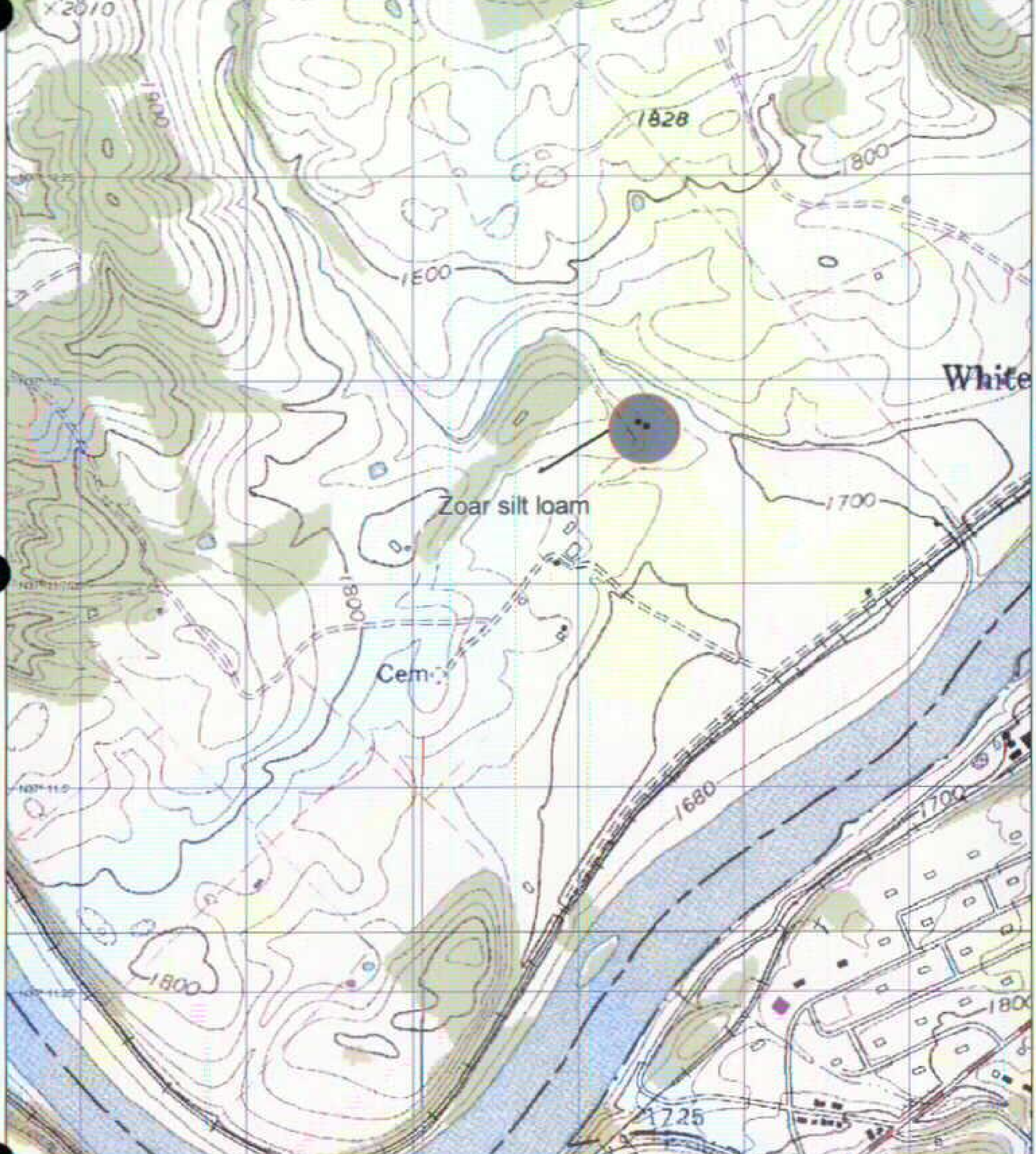
Percentage of Time column refers to the percent of time the water was present within the depth range.

Cumulative Days column refers to the total number of days the water was present within the depth range.

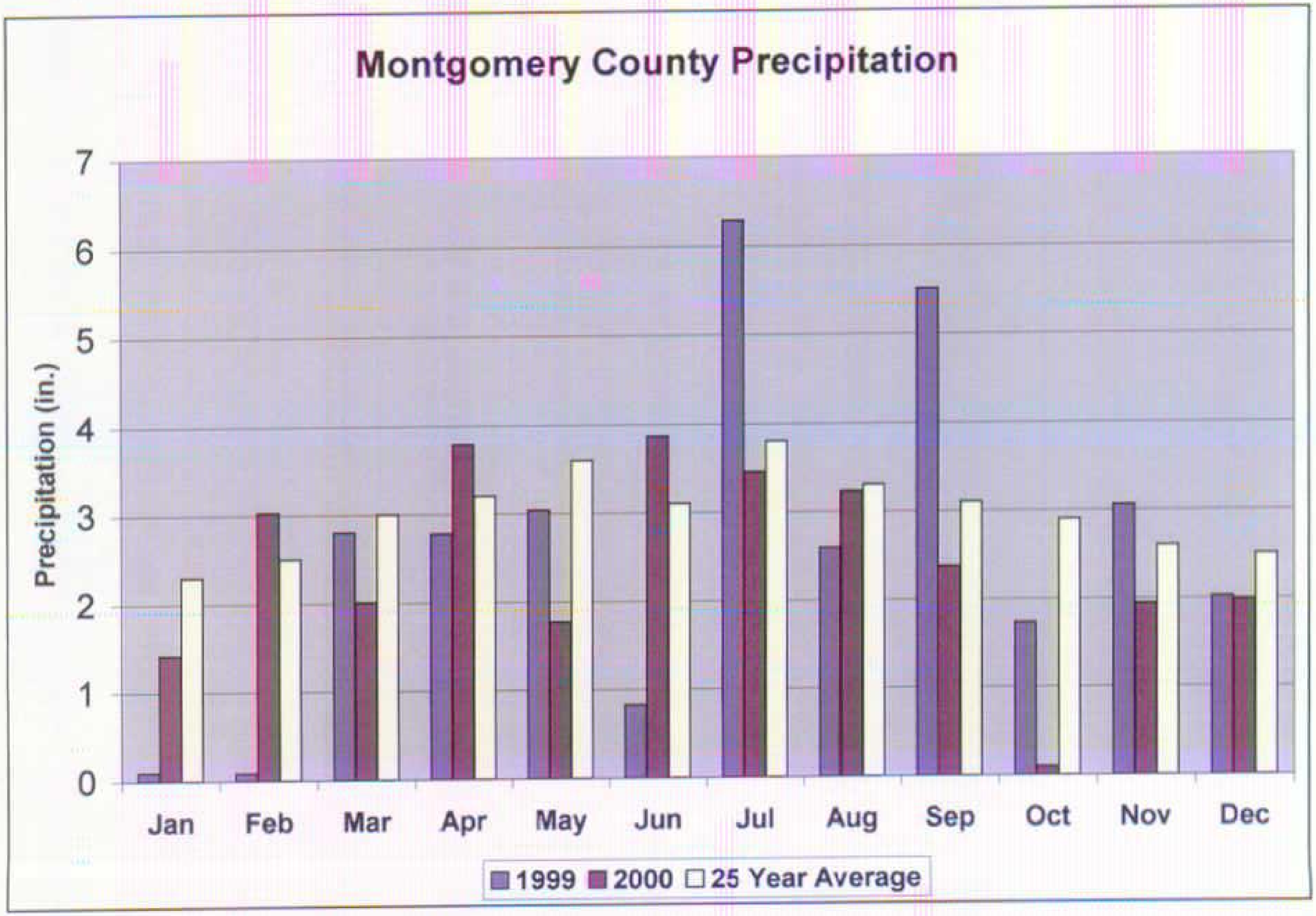
Percentage of Cumulative Days refers to the percent of total time the water was present within the depth range.

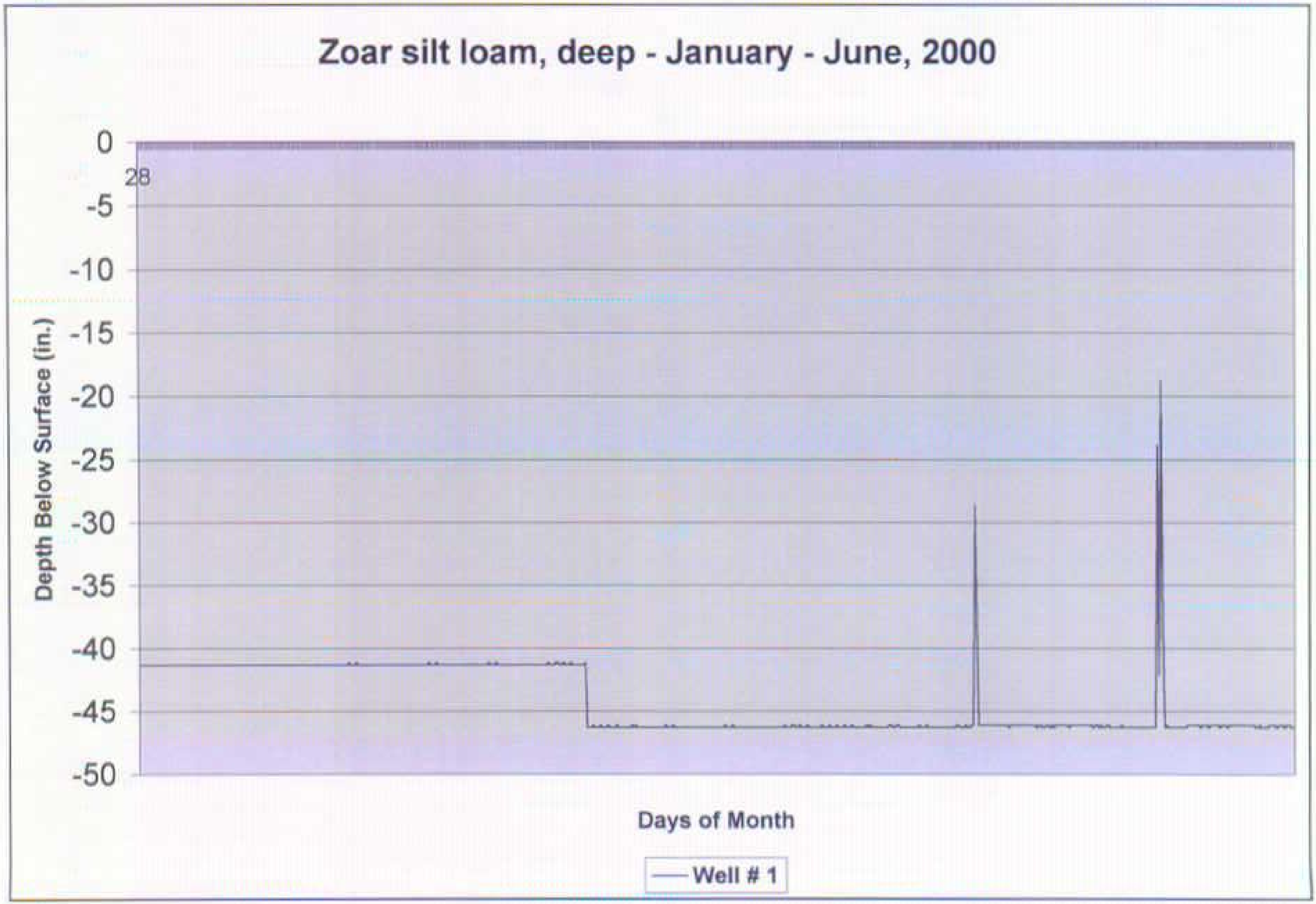
DRY corresponds to the number of readings (converted to days) where the monitoring well recorded no water in the hole.

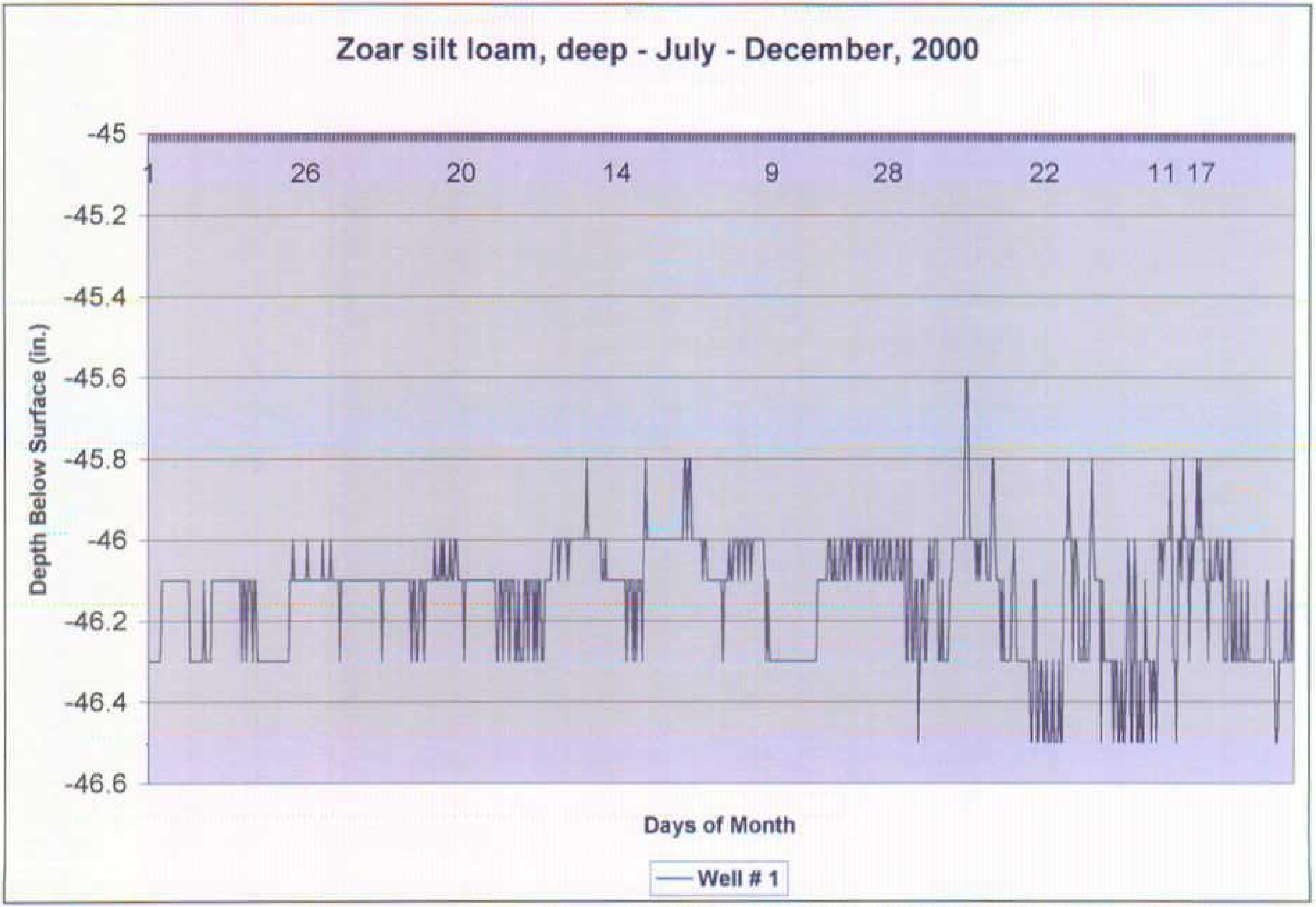
Days in the column headings corresponds to the number of data logger readings within a depth range divided by the number (normally 2, 4 or 8) of data logger readings per day.

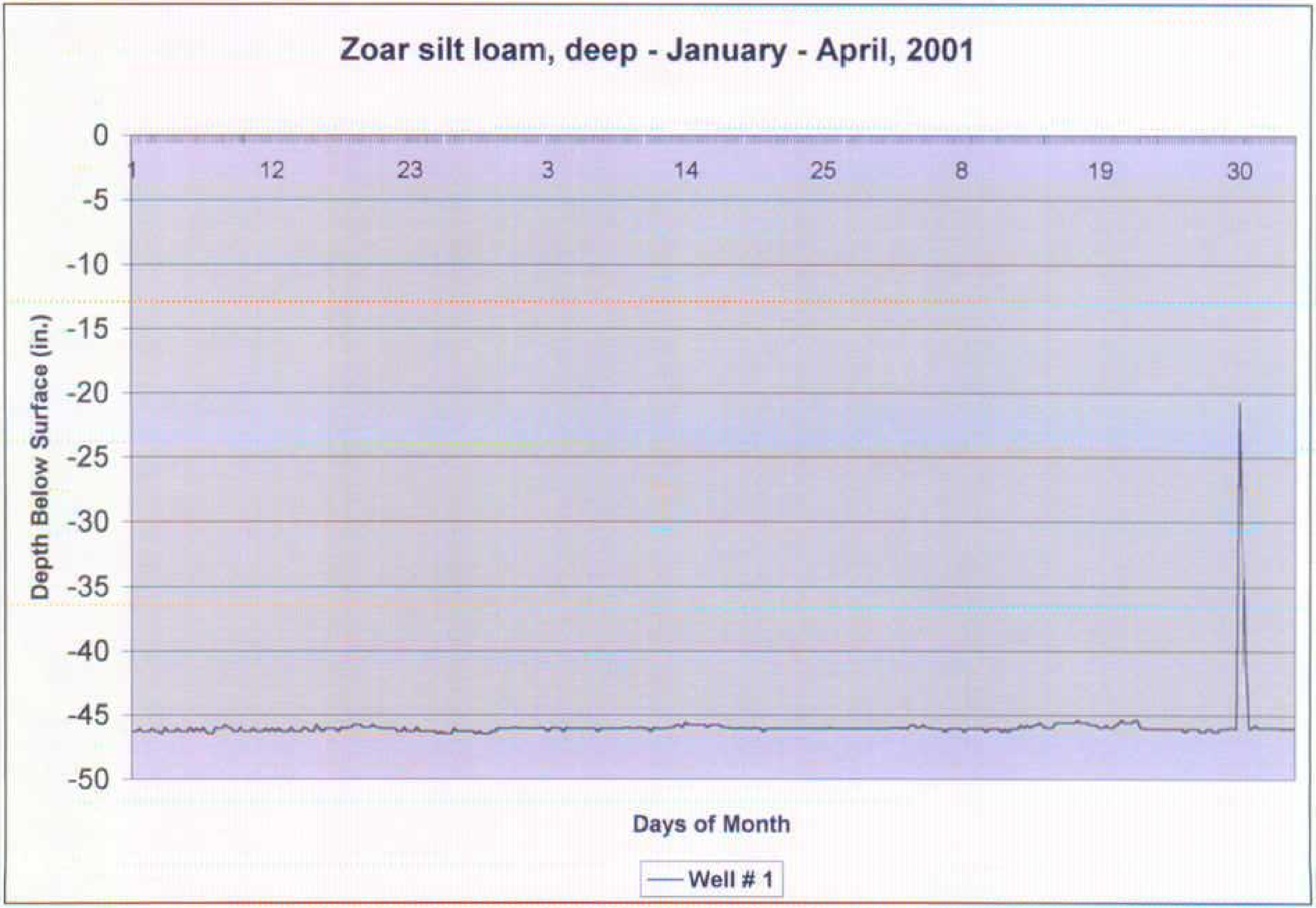


3-D TopoQuads Copyright © 1999 DeLorme Yarmouth, ME 04096 Source Data: USGS 450 ft Scale: 1 : 12,000 Detail: 14-0 Datum: WGS84


Montgomery County Precipitation
Precipitation (in.)
0
1
2
3
4
5
6
7
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
1999
2000
25 Year Average


Zoar silt loam, deep - January - June, 2000
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
28
Depth Below Surface (in.)
Days of Month
Well # 1


Zoar silt loam, deep - July - December, 2000
Depth Below Surface (in.)
-45
-45.2
-45.4
-45.6
-45.8
-46
-46.2
-46.4
-46.6
1
26
20
14
9
28
22
11
17
Days of Month
Well # 1


Zoar silt loam, deep - January - April, 2001
Depth Below Surface (in.)
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
1
12
23
3
14
25
8
19
30
Days of Month
Well # 1

SOIL EVALUATED: Zoar silt loam

LOCATION:

This research site was located in the northern portion of Montgomery County, Virginia. Refer to the accompanying portion of the U.S. Geologic Survey Radford North topographic map for the general character of the area. The topographic portion also indicates the general location of the WL-20 data logger.

RATIONALE FOR SITE SELECTION:

There were several reasons for selecting this site. First, I have earlier data from a previous water table study completed several years earlier that would be · verified with additional data.' Second, there were shallow horizons present that were thought to be slightly restrictive to downward water movement that would show up with a longer study period. Hence as part of the second idea, I was trying to determine at this site, was the water table here perched, did it rise from lower depths or were both suggestions correct? The soil had a high amount of manganese present in the profile and manganese is viewed as a soil wetness feature when discussing water movement in the soil.

SOIL AND SITE INFORMATION:

The soil at this site formed in moderately fine textured alluvial sediments on a terrace tread of the New River. There was a short, moderately steep hillside that lies upslope 100 yards of the site. The site was on a middle level terrace tread with a slope of 2 percent. The wells were in a fescue grass buffer area at the edge of a cornfield.

The site was evaluated as part of a special study. The soil was classified as Zoar silt loam by the participants of the study.' A very detailed soil profile description was made at the site and is included. The profile description was written by Dr. William Edmonds and Dr. Pamela Thomas of the Crop and Soil Environmental Sciences Department. When compared to the official soil series description for the Zoar series (refer to the Appendix), the soil at this site falls within the range of characteristics. That means the soil was typical or representative of Zoar soils.

This site is not suitable for conventional onsite systems as approved by the Virginia Department of Health. If it were not for the nearby stream, spray irrigation would be a consideration as a solution to the high water table problem at the site.

CLIMATIC DATA FOR THE SITE:

The site was less than 1 mile from the Kentland weather station, where official NOAA weather data are collected, so precipitation data from the station was used to evaluate rainfall during the study pedod. The precipitation comparison graph shows how rainfall totals each month compares to the monthly 25-year averages (1965-1990) of Montgomery County.

It is apparent that for the January-December 1999 period, precipitation was below normal with only three months having near or exceeding the 25-year average. Storms of July and September delivered almost 5 inches more rain than normal. The last three months of 1999 were dry and water tables would be expected to be lower in the soil profile.

For the period January-June 2000, total precipitation was nearly 2.0 inches below the 25-year average. That means the water table levels might be slightly lower than expected under normal conditions at the site.

For the period July-December 2000, monthly rainfall was below normal by 5.0 inches. It is noteworthy that only 0.01 inches of rain was recorded for the entire month of October 2000, making it the driest October since data collection began in southwest Virginia. The October-December 2000 period was extremely dry. In fact, rainfall was only 49% of the long-term average for that 3 month span. Therefore, the'water table levels at the site would be expected to be definitely lower than during a fall with normal precipitation..

Except for a few exceptional wet months the overall precipitation situation was one of below normal to near' drought conditions. It should be noted that the original project completion date 'was extended due to severe drought conditions in most of the state during 1999. The entire year 2000 was also well below normal. Southwest Virginia is in the fourth year in a row with below normal precipitation. As of November 24, 2001, the area is close to 13 inches below normal precipitation levels for the year.

RESULTS:

An automated WL-20 data logger was installed on FebruarY 4, 2000. The well location was placed to be representative of the soil conditions at the site. There was continuous data collection from the starting date until February 2001 when the well was extracted.

The Zoar soil at this site had common light gray (10YR 6/1) mottles (or iron depletions) below 23 inches in the Btcl horizon, making it a moderately well drained soil. Normally, it would be assumed that the seasonal water table would be below 23 inches, while there might be brief periods where it was above that depth. These soils are believed to have a perched water table. The mottled horizons below were believed to be restrictive. The mottling at shallower depths in the Btcl and Btc2 horizons was suspected to be associated with the fluctuating seasonal water table.

The February - June 2000 Groundwater Data Table showed a graph that has not yet been interpreted. The graph and data was mailed to Remote Data Sensing In August 2001. It is thought the problem might lie within the data logger and not be operator error from preliminary conversations with staff members of RDS. An explanation is unavailable at this time, December 2001. The "sail" pattern has appeared before from other research studies according to RDS. Therefore, the correct explanation for this graph is not available at this time.

The July-December 2000 hydrograph shows many readings between depths of 19.8 and 21 inches, with nearly all the readings between 20 and 21 inches. The short steep spikes on the hydrograph are .2 to .3 tenths of an inch in length. The timing of the spikes' may refer to rain events. In October, perhaps the driest month ever in southwest Virginia, there was not any real difference in the spikes. The water level rose to the 20-20.4 inch range from the depth of 21 inches in September when there were 5.5 inches of rain.

The numerous recordings between 20 and 21 inches may be condensation that has fallen or dripped from the housing unit. Or the readings may mean nothing more than moisture held by soil that has slipped through the housing screen during installation or after rain events.

The July-December 2000 Groundwater Data Table showed that free water was in the BA horizon for 184 days. The base of the B^ horizon is 23 inches, 3 inches longer than the data logger design. For less than 2% of the time during this 184 day period the water level was within the 18.1-20 inch depth range. For 90% of the time the data logger had readings between 20.1 and 21.1 incheS. "Dry" was typed beside this depth range because it should be considered as dry even with measurements recorded.

The January-February 2001 hydrograph shows mainly dry hole readings in January with two spikes in the last eleven days of the month. On this graph the dry hole line would be below 20.9 inches. The Groundwater Table Data lists 6.5 days in the 20.5-20.9 inch depth range and 30 days in the dry level below 21.9 inches. Explanations for the numerous readings in the very narrow depth span are mentioned in the above paragraphs.

CONCLUSIONS:

This site had precipitation levels well below normal for the majority of the study period. The depth to free water was much greater than where gray mottles were observed in the soil. If the free water table rose 0.2 tenths of an inch in the soil, it was there for only a very short period of time.

Free water was never observed in the data logger wells or in sections of the old Pit. For the entire study period, free water was not visible because of the drought. Water levels in 1999 were Iow and have never risen to their previous levels. This simple fact suggests when soil moisture levels are being studied during or following a drought, the time period should be extended or the grant period frozen until some semblance of normal weather patterns return.

The soil morphologic features that are usually related to the presence of water in the soil become extremely important during drought periods. In other words, there were no data logger readings recording that this soil is wet. Under normal precipitation levels the water table would be within eighteen inches of the surface during the winter months. It would be expected that the perched water table would be in the Btcl horizons for significantly longer periods of time after major rain events during the drier summer and fall months.

The location of this site was on a terrace tread, with a short steep upslope watershed about 100 yards should have contributed some moisture to the site. During the winter-spring periods when plants were dormant and exapotranspiration was very Iow, excess moisture not held in the soil should have moved downslope towards this site. None of the movement was ever noted by the data logger or by personal observation. In the spring when plants leafed out to start their growth patterns no observable change was noted on the hydrograph.

As was noted eadier, this soil did not satisfy the minimum state requirements for a conventional gravity drainfield, based on soil morphology and landscape position. Based on the fourteen-month monitoring period studied, it is apparent that if a conventional septic system had been installed, the gravel filled trenches would not have had water present during the year of 2000. Soil morphology indicated this soil was unsuitable for a conventional gravity drainfield.

The manganese concretions were not explained due to the absence of the water table. A future study with normal moisture patterns would be valuable at this site.

Fourteen months of monitoring data taken while there was below normal precipitation did not show the soil was unsuitable due to a high water table. This fact highlights the importance of making correct soil evaluations using soil morphology clues during the VDH permitting process.

If a study needs to focus in a depth range of 19 to 22 inches, then the participants should use the longer and therefore deeper WL-40 data logger. Study resources of time and money are too important to risk to questionable data. A manual well should be. placed near the data logger well for the same reasons of time and money. An auger hole should be bored each month to obtain a better visible picture of what is happening in the soil.

When using the RDS system for a study, the participants should be very familiar with the graphing or handling of data before the study starts. With that knowledge, short quick graphs could be made to review the progress of the study in order to locate problems early in the study.

Zoar silt loam

Profile for Well # 1: (WL20)

Ap--0 to 10 inches; dark grayish brown (10YR 4/2), broken, silt loam; moderate medium granular structure; .friable, non-sticky, non-plastic; many fine and medium roots; many fine and very fine tubular and vesicular pores; moderately acid; abrupt wavy boundary.

BA--10 to 23 inches; yellowish brown (10YR 5/4), broken, loam; weak medium subangular blocky structure; friable, slightly sticky, slightly plastic; common very fine and fine roots; common fine and very fine tubular and vesicular pores; strongly acid; gradual wavy boundary.

Btcl--23 to 32 inches; yellowish brown (10YR 5/8), broken, sandy clay loam; many medium distinct brownish yellow (10YR 6/4), broken, and light gray (10YR 6/1), broken, iron and manganese redox depletions; moderate medium subangular blocky structure; firm, slightly sticky, slightly plastic; common very fine and fine roots; few medium vesicular pores; few distinct brown (10YR 5/3), broken, clay films on faces of peds and in pores; common medium irregular black (10YR 2/1), broken, manganese and iron nodules and masses with diffuse boundaries; moderately acid; diffuse smooth boundary.

Btc2--32 to 47 inches; yellowish brown (10YR 6/8) broken, clay loam; many medium distinct pale brown (10YR 6/3), broken, and light gray (N 7/0), broken, iron and manganse redox depletions; moderate medium and fine subangular blocky structure; firm, slightly sticky, slightly plastic; few very fine roots; few fine and medium vesicular pores; many distinct brown (10YR 5/4),' broken, clay films on faces of peds and in pores; many medium rounded black (10YR 2/1), broken, manganese and iron nodules and masses with diffuse boundaries; moderately acid; diffuse smooth boundary.

Btc3-- 47 to 68 inches; yellowish brown (10YR 5/8) broken, loam; many medium distinct pale brown (10YR 613), broken, and light gray (10YR 6/1), broken, iron and manganese redox depletions; weak coarse platy structure; firm, slightly sticky, slightly plastic; few very fine roots; few fine and medium vesicular pores; many prominent brown (10YR 5/3), broken, clay films on faces of peds and in pores; common medium irregular black (10YR 2/1), broken, iron and manganese nodules and masses with diffuse boundaries; strongly acid; clear smooth boundary.

2Btc4-68 to 76 inches; yellowish brown (10YR 5/4), broken, gravelly sandy clay. loam; many medium distinct pale brown (10YR 6/3), broken, iron and manganese redox depletions; weak medium platy structure; friable, slightly sticky, slightly plastic; few very fine roots; common fine and medium vesicular pores; many prominent yellowish brown (10YR 5/4), broken, clay films on faces of peds and in pores; many medium irregular very dark gray (N 3/0), broken, and black (10YR 2/1), broken, iron and manganese nodules and masses with diffuse boundaries; 20 percent rounded quartz gravels and 5 percent rounded quart7_ cobbles; very strongly acid; clear smooth boundary.

3Bt-76 to 91inches; strong brown (7.5YR 5/6), broken, sandy clay loam; weak medium platy structure; friable, slightly sticky, slightly plastic; few very fine roots; few medium vesicular pores; common prominent brown (10YR 5/3), broken, clay films on faces of peds and in pores; few medium irregular black (10YR 2/1), broken, iron and manganese nodules and masses with diffuse boundaries; 2 percent rounded quartz, angular chert, and irregular shale gravels; very strongly acid.

Remarks: This profile description taken from an excavated pit by Dr. William Edmonds and Dr. Pamela Thomas of VPI & SU Crop and Soil Environmental Sciences Department during August 1992. The pit was excavated in a rescue grass field.

Table 1 - - Zoar silt loam Groundwater Data Table
February - June, 2000 (145 Days)
Kentland, Data Logger Well # 1

Well # 1
Percent

Depth Range (in.)	Number of Days	Percent Time	Cumulative Days	Cumulative Days
0-6	0	0	0	0
6.1-12	0	0	0	0
12.1-18	0	0	0	0
18.1-20	0	0	0	0
20.1-21	3	2	3	2
21.1-22 (Dry)	142	98	142	98

Table 2 - - Zoar silt loam Groundwater Data Table
July - December, 2000 (184 Days)
Kentland, Data Logger Well # 1

Well # 1
Percent

Depth Range (in.)	Number of Days	Percent Time	Cumulative Days	Cumulative Days
0-6	0	0	0	0
6.1-12	0	0	0	0
12.1-18	0	0	0	0
18.1-20	1	1	1	1
20.1-21.1(Dry?)	165	90	166	90
DRY	18	9	184	100

Number of Days column refers to the number of days the surface of the free water was present within the depth range.

Percentage of Time column refers to the percent of time the water was present within the depth range.

Cumulative Days column refers to the total number of days the water was present within the depth range.

Percentage of Cumulative Days refers to the percent of total time the water was present within the depth range.

DRY corresponds to the number of readings (converted to days) where the monitoring well recorded no water in the hole.

Days in the column headings correspor~ds to the number of data logger readings within a depth range divided by the number (normally 2, 4 or 8) of data logger readings per day.

Table I - - Zoar silt loam Groundwater Data Table

January - February, 2001 (37 Days)

Kentland, Data Logger Well # 1

Well # 1 ~'

I

Depth Range (in.)	Number of Days	Percent Time	Cumulative Days	Percent Cumulative Days
0-6	0	0	0	0
6.1-12	0	0	0	0
12.1-18	0	0	0	0
18.1-20.4	0	0	0	0
20.5-20.9	7	19	7	19
DRY	30	81	37	100

Number of Days column refers to the number of days the surface of the free water was present within the depth range.

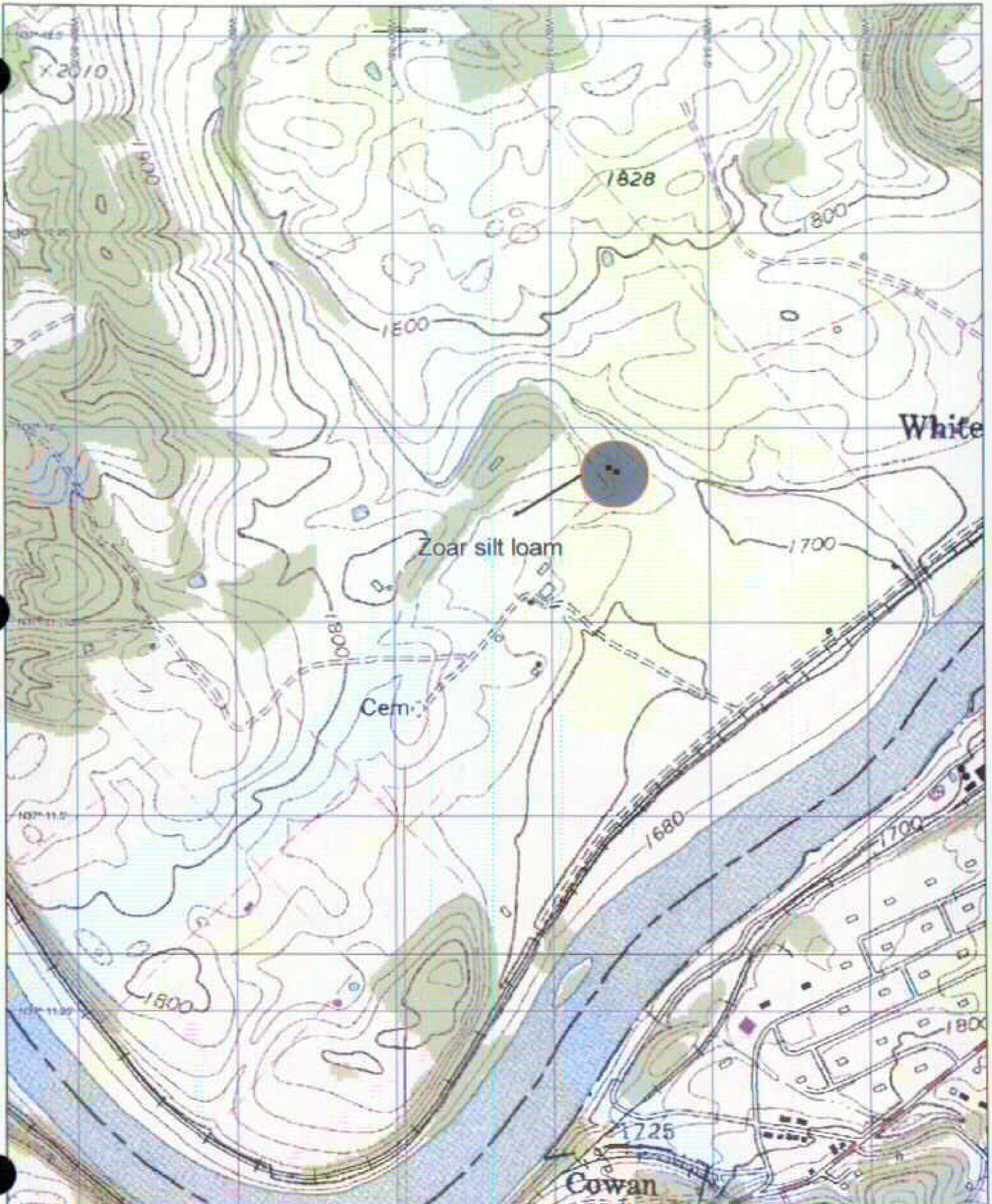
Percentage of Time column refers to the percent of time the water was present within the depth range.

Cumulative Days column refers to the total number of days the water was present within the depth range.

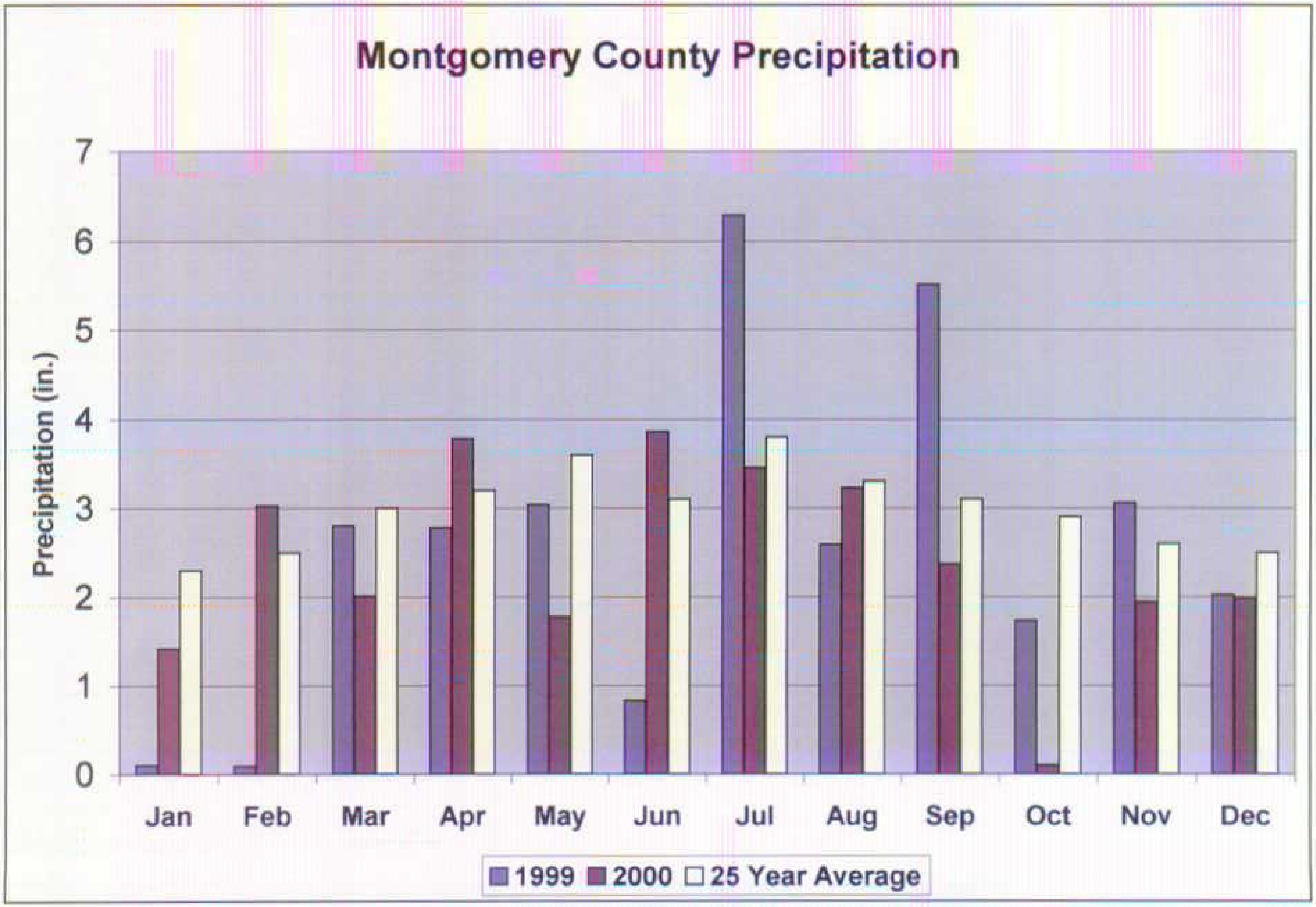
Percentage of Cumulative Days refers to the percent of total time the water was present within the depth range.

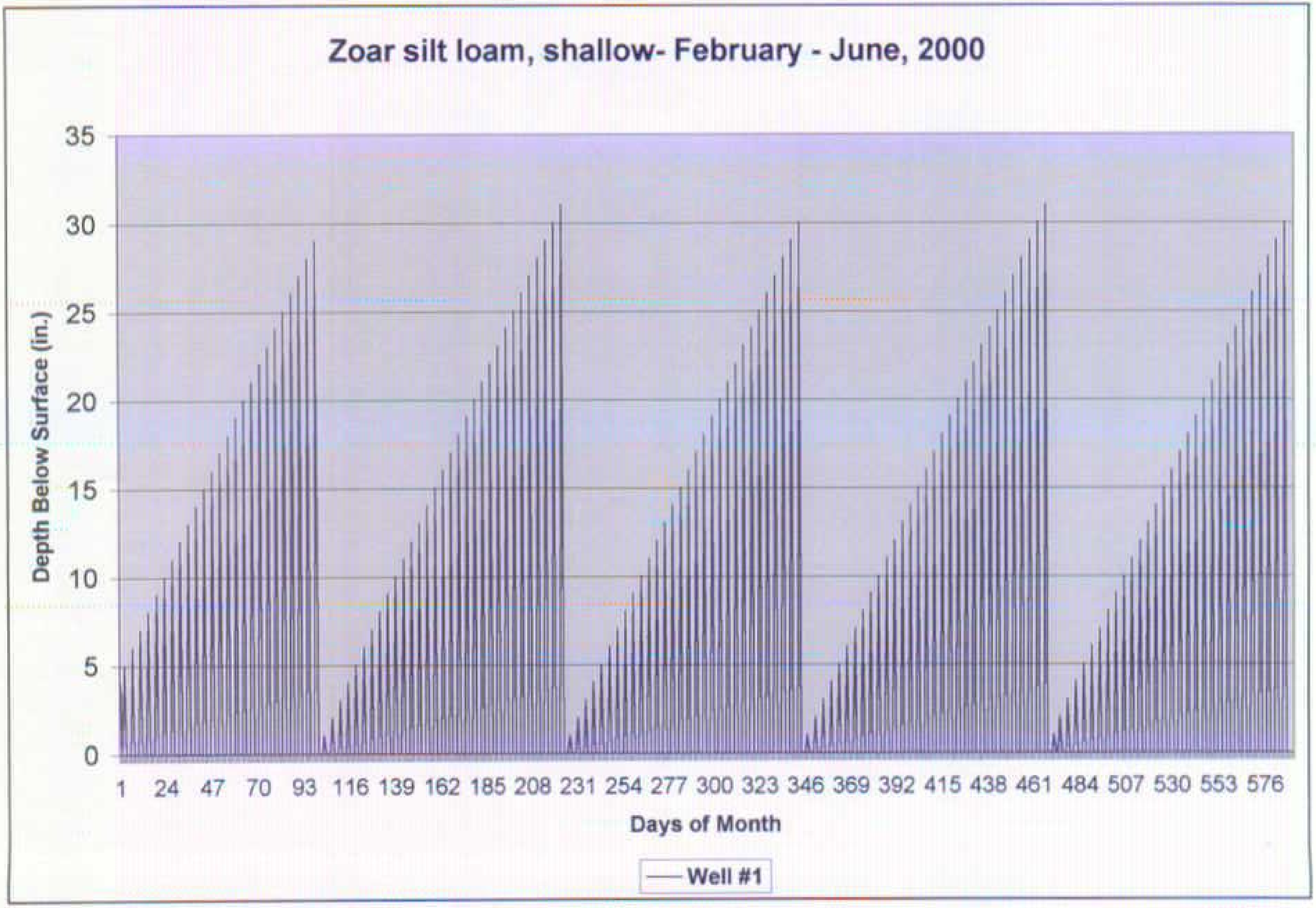
DRY corresponds to the number of readings (converted to days) where the monitoring well recorded no water in the hole.

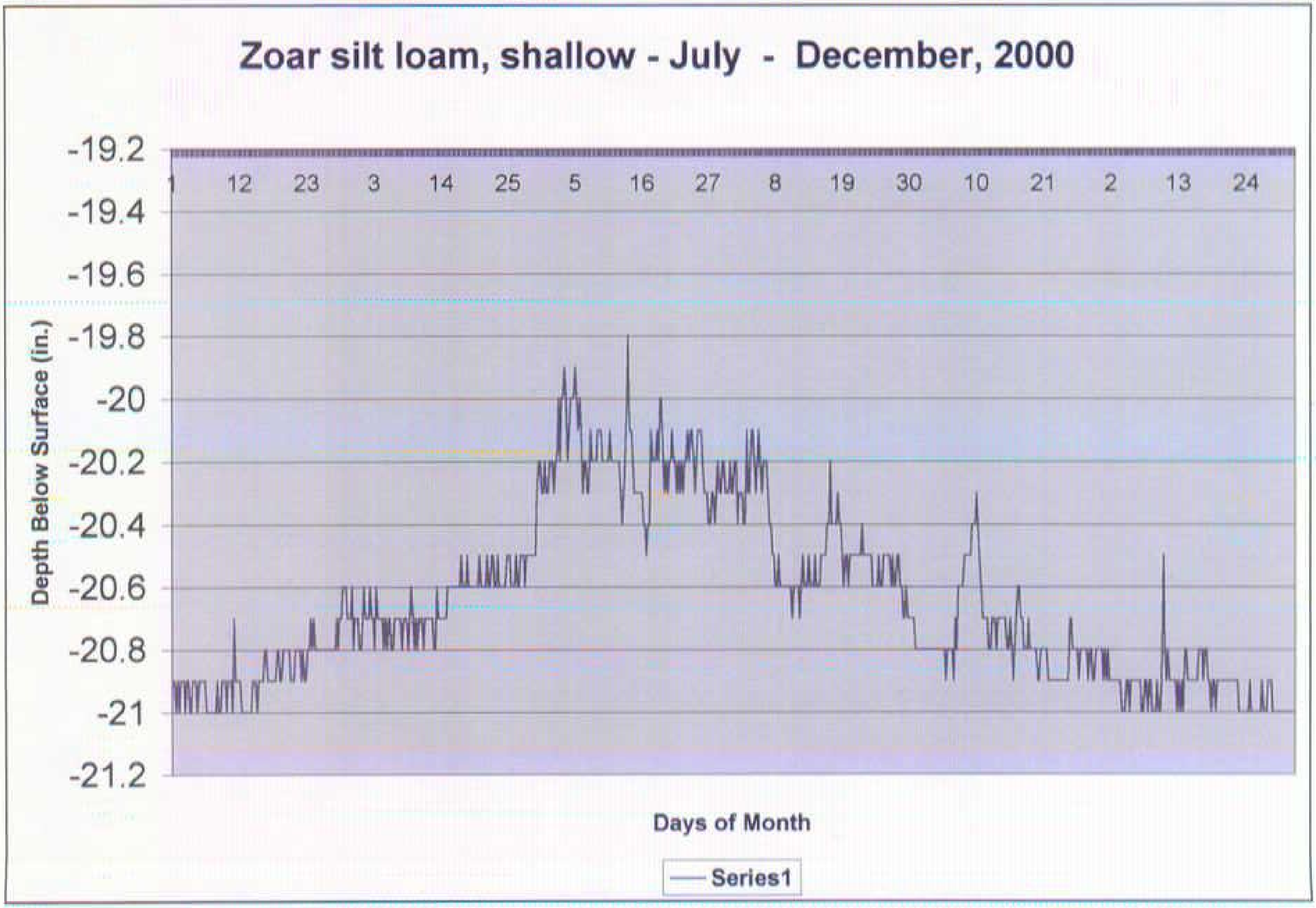
Days in the column headings corresponds to the number of data logger readings within a depth range divided by the number (normally 2, 4 or'8) of data logger readings per day.



 450 ft Scale: 1 : 12,000 Detail: 14-0 Datum: WGS84

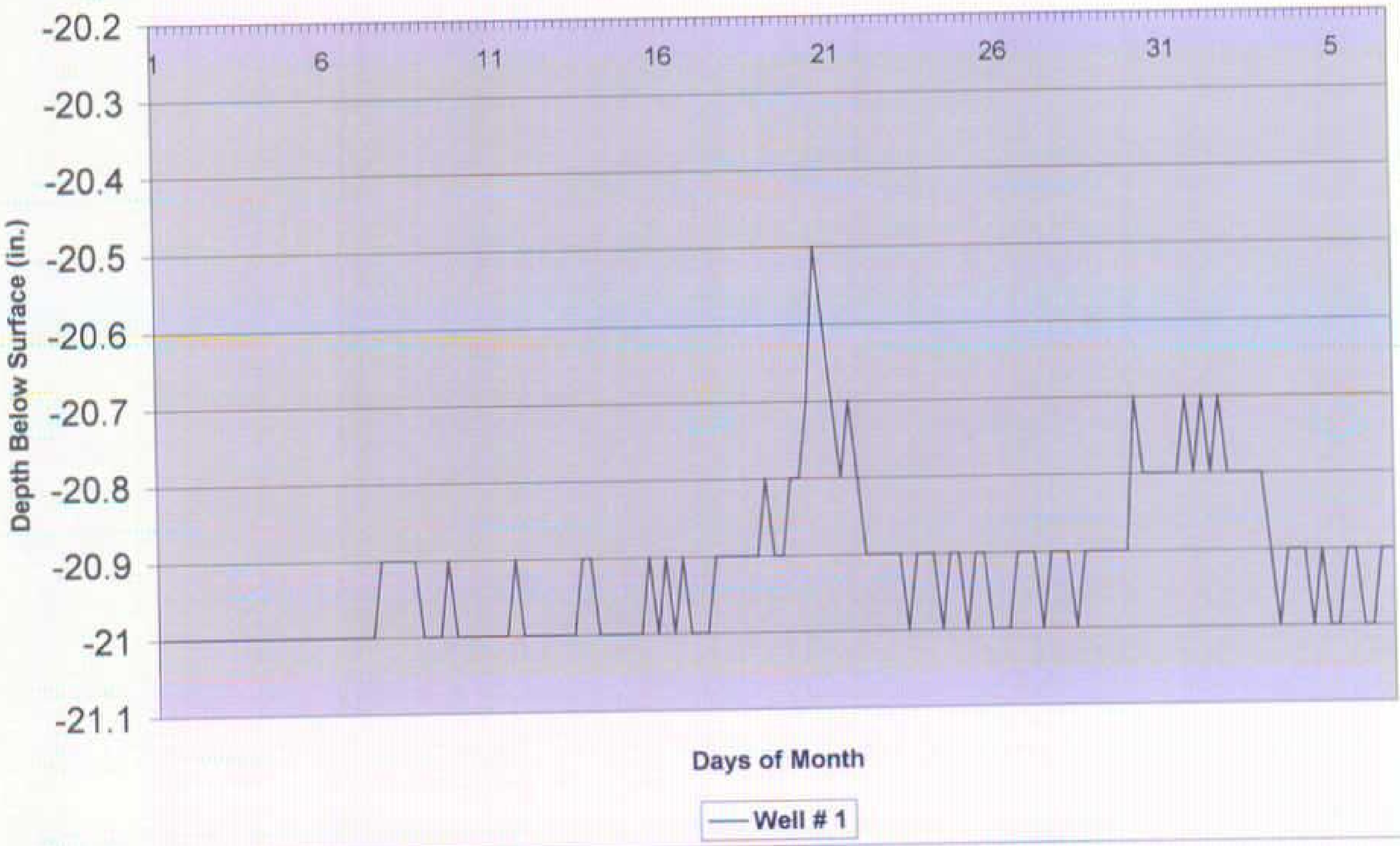

Montgomery County Precipitation
Precipitation (in.)
7
6
5
4
3
2
1
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
1999
2000
25 Year Average


Zoar silt loam, shallow- February - June, 2000
Depth Below Surface (in.)
35
30
25
20
15
10
5
0
1 24 47 70 93 116 139 162 185 208 231 254 277 300 323 346 369 392 415 438 461 484 507 530 553 576
Days of Month
Well #1



Zoar silt loam, shallow - July - December, 2000
Depth Below Surface (in.)
-19.2
-19.4
-19.6
-19.8
-20
-20.2
-20.4
-20.6
-20.8
-21
-21.2
1
12
23
3
14
25
5
16
27
8
19
30
10
21
2
13
24
Days of Month
Series1

Zoar silt loam, shallow - January - February, 2001



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Appendix A

LOCATION ACKWATER VA

Established Series
DLJ-DDR, Rev MHC
07/1999

ACKWATER SERIES

Soils of the Ackwater series are very deep and moderately well drained with slow permeability. They formed in fluvial sediments. They are nearly level to steep soils On the Coastal Plain. Slopes range from 0 to 25 percent. Mean annual precipitation is about 42 inches and mean annual temperature is about 59 degrees F.

TAXONOMIC CLASS: Fine, mixed, subactive, thermic Aquic Paleudults

TYPICIAL PEDON: Ackwater silt loam-on a 4 percent slope. Colors are for moist soil unless otherwise stated.)

A--0 to 5 inches; light yellowish brown (2.5Y 6/4) silt loam; moderate medium granular structure; friable, slightly sticky, slightly plastic; common fine mots; extremely acid; clear smooth boundary. (2 to 6 inches thick)

Btl--5 to 9 inches; yellowish brown (IOYR 5/6) silty clay loam; weak medium subangula~ blocky structure; friable, sticky, slightly plastic; few medium roots; few very fine pores; few faint discontinuous clay films on faces of peds; extremely acid; clear smooth boundary.

Bt2--9 to 16 inches; yellowish· brown'(1OYR 5/8) siltycla3~ loam; moderate ~medium subangular blocky structure; firm, sticky, plastic; few fine roots; few very fine pores; common prominent clay films on faces ofpeds; very strongly acid; gradual smooth botmdary.

Bt3--16 to 28 inches; strong brown (7.5YR 5/8) silty clay; many coarse distinct light gray (1OYR 7/1) iron depletions and common medium prominent red 2. SYR 4/8) masses of iron accumulation; weak coarse prismatic structure parting to moderate medium subangular blocky; finn, sticky, plastic; few fine roots; few very fmc pores; common prominent clay films on faces of peds;
very strongly acid; gradual wavy boundary.

Bt4--28 to 52 inches; mottled strong brown (7.SYR 5/8), light gray (IOYR 7/1), red (2.SYR 4/8), and brownish yellow (1OYR 6/8) silty clay; moderate coarse prismatic structure parting to moderate very thick platy, parting to moderate medium ang~alar blocky; firm, sticky, plastic; few very fine mots along faces ofpeds; common prominent clay
films on faces ofpeds; very strongly acid; gradual smooth boundary.

Btg--52 to 72 inches; light gray (2.5Y 7/0) silty clay; many coarse distinct strong brown (7.5YR 5/8) and red (2.5YR 4/8) masses of iron accumulation; weak coarse prismatic structure parting to weak thick platy parting to moderate fine subangular blocky; very f'n-m, sticky, plastic; common prominent clay films on faces ofpeds; very strongly acid. (Combined thickness of the Bt horizon ranges from 50 to 80 inches)

TYPE LOCATION: Princ~ George County, Virginia at ?rinee George Courthouse; approximately 2,400 feet east of junction of YA-106; VA-634, and 150 feet north of Crregory Chapel in the woods.

RANGE IN CI:L~.!~_CTER!STICS: Solum thickness is more than 60 inches. Content of rock fragments ranges from 0 to 2 percent throughout the soil. The soil ranges from extremely acid through strongly acid unless limed. Aluminum saturation on the exchanges complex is commonly greater than 50 percent, and commonly ranges from 5 to 15 meq/100 grams of soil.

The A horizon has hue oflOYR or 2.5Y, value of 4 through 6, and chroma of 1 through 4. Texture is silt loam, loam, or fine sandy loam. In eroded areas, texture is silty clay loam or clay loam.

The E horizon,where present, has hue of 1OYR or 2.5Y, value of 5 through 7, and chroma of 2 through 4. Texture is silt loam, loam, or fmc sandy loam.

The BE horizon, where presem, has hue of 7.5YR through 2.5Y, value of 4 through 6, and chroma o~ 4 through 8. Texture is loam, silt loam, clay loam, or silty clay loam.

The upper part of the Bt horizon has hue of 7.5YR through 2.5Y, value of 5 or 6, and ckroma of 4 through 8. Texture is clay loam, silty clay loam, silty clay, or clay.

The lower part of the Bt horizon and the BC horizon, where present, is neutral or has hue of 1OYR or 2.5Y, value of 5 through 7, and chroma of 0 through 8 or. They axe multicolored in shades of brown, gray, yellow and red. Texture is clay loam, silty clay loam, silty clay, or clay.

COMPETING SERII~S: (This section not reviewed this date; series reclassified as fine and subactive) These are the Angie, Chrysler,and Tiak. Similar soils in related families include Caroline, ~, and Persanfi. Angie soils have an appar-~% ;~vater table at 36 to 60 inches and climatic conditions w~h result m----Tower crop yields. Chrysler soils dominately have redder hue in the Bt horizon and low shrink-swell potential in the substratum. Tiak soils have hue of 5YR or redder in the Bt horizon. Caroline soils do not have low chroma mottles within 30 inches of the surface. Duplin and Persanti soils have kaolinitic mineralogy. -~

GEOGRAPHIC SETTING Ackwater soils are on nearly level to steep landscapes of the upper Coastal Plain. They formed in fluvial sediments. Slopes range from 0 to 25 percent. Mean annual temperature is 59 degrees F., and mean annual precipitation is 42 inches near the type location. Elevation at type location is about 130.feet.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the Ayeoek, Emporia, Montross, Norfolk, and Kinston soils. Aycock and Montross soils are on similar landscape Positions and have a fm~ parta~ control section. In addition, Montross soils have between 40 and 60 percent brittleness in the Bt horizon. Emporia and Norfolk soils have a fmc-loamy particle-size control section. Kinston soils are on nearby floodplains and are frequently flooded.

DRAINAGE AND PERMEABILITY: Moderately well drained; slow to rapid runoff; slow permeability. A perched water table is at a depth o£ ! B to 36 inches below the surface from late fall through early spring.

USE AND VEGETATION: Aekwater soilg are used primarily for woodland and some pasture. The woodland is mixed hardwoods and pine. A small acreage is used for cropland. The principal crops are eom, soybeans, wheat and barley. Important tree species include loblolly pine, southern red oak, white oak, yellow-poplar, and sweetgum.

DISTRIBUTION AND EXTENT: Coastal Plain in Virginia and possibly North Carolina, and Alabama. This series is of moderate extent.

MLRA OFFICE RESPONSIBLE: Raleigh, North Carolina

SERIES ESTABLISHED: Prince George County, Virginia; 1980.

REMARKS: These soils Have been included with the Duplin series in past mapping.
Diagnostic Horizons and features recognized in this pedon are:
a. A Quic- 2 chroma mottles in the top 30 inches of the argillic, b. Argillie Horizon - Between 9 and 72 inches.

c. Palic - Clay does not decrease by 20 pereem, from 40 inches of the surface of the Argillic:

ADDITIONAL DATA: Particle-size, chemical, and mineralogy data are available for the typical pedon (77 VA 149-27-(2-4). Data is from VPI soils Lab.

TABULAR SERIES DATA:

SOX-5	Soil Name	Slope	Airtemp	FrFr/Seas	Precip	Elevation
VA0142	ACKWATER	0- 25	59- 63	190-240	40- 52	5- 250

SOI-5	FloodL	FloodH	Watertable	Kind	Months	Bedrock	Hardness
VA0142	NONE		1.5-3.0	PERCHED	NOV-MAR	60-60	

SOI-5	Depth	Texture	3-Inch	No-10	Clay%	-CEC-
VA0142	0- 5	FSL L SIL	0- 0	95-100	8-15	~
VA0142	0- 5	CL SICL	0- 0	95-100	27-40	-
VA0142	5-16	L CL SICL	0- 0	95-100	25-40	-
VA0142	16-72	SICL SIC C	0- 0	95-100	35-60	-

SOI-5	Depth	-pH-	O.M.	Salin	Permeab	Shnk-Swll
VA0142	0- 5	3.6- 5.5	.5-2.	0- 0	0.6- 2.0	LOW
VA0142	0- 5	3.6- 5.5	.3-.8	0- 0	0.2- 0.6	MODERATE
VA0142	5-16	3.6- 5.5	0.-.5	0- 0	0.2- 0.6	MODERATE
VA0142	16-72	3.6- 5.5	0.-.5	0- 0	0.06- 0.2	HIGH

National Cooperative Soil Survey
U.S.A.

LOCATION ACREDALE VA+NC

Established Series
DRH, JHW, RL¥
06/2000

ACREDALE SERIES

Soils of the Aeredale series are very deep and poorly dxained. They formed in silty and loamy marine and fluvial sediments on the lower Coastal Plain. Permeability is slow and runoff is slow or ponded. Mean annual temperature is 59 degrees F, and mean annual precipitation is 45 inches near the site location. Slopes range from 0 to 2 percent.

TAXONOMIC CLASS: Fine-silty, mixed, active, thermic Typic Endoaqualfs

TYPICAL PEDON: Acredale silt loam - in a nearly level cultivated field. (The soil was moist throughout when described.)

Ap--0 to 7 inches; grayish brown (10YR 5/2) silt loam; weak fine granular structure; very friable, slightly sticky, slightly plastic; common fine and very fine roots; common f'me and medium pores; strongly acid; clear smooth boundary. (6 to 12 inches thick)

Btgl--7 to 15 inches; light brownish gray (10YR 6/2) silt loam; few fine prominent yellowish brown (10YR 5/8) mottles; weak medium subangular blocky structure; friable, slightly sticky, slightly plastic;- common f'me and very fine roots; common very fmc vesicular and few f'me tubular pores; many very f'me sand grains coated and bridged with clay; very strongly acid; abrupt smooth boundary. (0 to 10 inches thick)

Btg2--15 to 35 inches; gray (SY 5/1)silty clay loam; common medium prominent yellowish brown (10YR 5/8) imped mottles; weak coarse prismatic structure parting to moderate medium and coarse subangular blocky; friable, sticky, plastic; cOmmon very fine roots; few fine vesicular and few fine tubular pores; many thin continuous clay films on faces of macro peds; many very f'me sand grains coated and bridged with clay; pockets of silt from 1/2 to 3 inches in diameter' that are white when dry; very strongly acid; clear smooth boundary.

Btg3--35 to 43 inches; mottled light greenish gray (5GY 7/1), dark gray (N 4/0), and yellowish brox,m (10YR 5/8) silt loam; moderate fine and medium subangular and angular blocky structure; friable, sticky, plastic; few very fine roots; few very fmc vesicular!pores; few thin discontinuous clay films on faces of peds; few very fine sand grains coated and bridged with clay; few fine prominent yellowish red colors along very fmc root channels; very strongly acid; clear smooth boundary. (Combined thickness of Bt horizon is 14 to 43 inches.)

2BCg--43 to 50 inches; mottled light gray (10YR 6/1), light greenish gray (5GY 7/1), and yellowish brown (10YR 5/8) sandy loam; weak medium subangular blocky structure; friable, slightly sticky, slightly plastic; few very f'me roots; few fine vesicular pores; few sand grains coated and bridged with clay; many clean sand grains; common pockets of clean white sand up to 3 inches in diameter; strongly acid; clear wavy boundary. (0 to 10 inches thick)

2Cg--50 to 66 inches; mottled gray (5Y 6/1), light olive gray (SY 6/2), and yellowish brown (10YR 5/8) sandy loam; massive, very friable; nonsticky, nonplastic; few very fine vesicular pores; many f'me flakes of mica; moderately acid.

TYPE LOCATION: City of Virgirfia Beach, Virginia; apProximately 4.5 miles northwest of Princess Anne, 1,700 feet south southwest of intersection of Lynhaven Parkway and Princess Anne Road.

RANGE IN CI-IARACTERISTICS: Solum thickness ranges from 40 to 60 inches. The A horizon ranges from extremely acid through strongly acid artless limed. The B and C horizons range from very strongly acid through neutral.

The A horizon has hue of 10YR or 2.5Y, value of 2 through 6, and chroma of 1 through 3. Horizons with value of 2 or 3 are less than 6 inches thick. The A horizon is silt loam, loam, or very fine sandy loam.

Some pedons have a BA horizon, that has hue of 10YR through 5Y or is neutral, value of 4 through 7, and chroma of 0 through 2. Few to many high chroma mottles are in most pedons. The BA horizon is loam or silt loam.

The Btg horizon has colors similar to the BA horizon and ranges to include hue of 5GY and 5G, value of 4 through 6, and chroma of 1. When present, the greenish colors axe generally in the lower part. Some pedons are mottled with high and low chroma mottles in the lower part of the Bt. Texture of the upper part of the Btg horizon is silty clay loam or silt loam, and texture of the lower part of the Btg horizon has similar textures and ranges to loam, clay loam, or. silty clay.

The BC horizon, where present, has colors and commonly has texture similar to those of the lower part of the Bt horizon and the middle Bt horizon. Texture also ranges to fmc sandy loam, sandy loam or sandy clay loam in some pedons.

The C horizon has colors similar to the B horizon. It dominantly is sand, loamy sand, very frae sandy loam, fine sandy loam or sandy loam, but thin strata of finer texture are common in most pedons.

COMPETING SERIES: These are the Adaton, Amagon, Routon, and Tichnox series in the same family and the Bladen, Cape Fear, Hyde,~and, Roanok-~'?m-d-Tom~ries in closely related families. Adaton soils have dark concretions in the B horizon and solurn thickness greater than 60 inches and more clayey lower Bt horizons. Amagon soils have a B horizon that contains dark concretions and a high content of very fmc sand and solum thickness of 50 to 70 inches or more. Routon soils formed in loess more than 4 feet thick and they have a B horizon that contaLns dark concretions. Tichnor soils have an A horizon with total thickness of 24 to 39 inches. Bladen, Cape Fear, Hyde, Roanoke, and Tomotley soils have a base saturation of less than 35 percent. In addition, Bladen, Cape Fear, and Roanoke soils are clayey, Hyde and Hydeland soils have an umbric epipedon, and Tomotley soils are fine-loamy.

GEOGRAPI-IIC SETTING: The Acredale soils are on nearly level sarfaces of the lower Coastal Plain, generally at elevations of less than .25 feet. They formed in silty and loamy marine and fluvial sediments. Slopes are less than 2 percent. Mean annual temperature is 59 degrees F, and the mean annual precipitation is 45 inches. The elevation at the site location is approximately 12 feet above mean sea level. :

GEOGRAPItlCALLY ASSOCIATED SOILS: In addition to the competing Cape Fear, Hyde, Hydeland, Roanoke, and Tomotley soils, these are the Augusta, Bojae, Dragston, State, ancVTei-6tum soils. All of these soils are better drained than Acredal6 soils, ancWaxe located on l~l~r parts of the landscape. In addition, Augusta, State, and Tetotum soils are frae-loamy; Bojac and Dragston soils are coarse-loamy.

DRAINAGE AND PERMEABILITY: Poorly drained; runoff is very slow or ponded. Permeability is slow. The water table commonly is at or near the surface during winter months in undrained areas. Slightly concave areas may be ponded briefly during periods of high rainfall.

USE AND VEGETATION: Most areas are in cultivated crops. These crops include corn, soybeans, wheat, and vegetable crops. Wooded areas are mainly in loblolly pine and mixed hardwood species.

DISTRIBUTION AND EXTENT: Virginia, North Carolina, and possibly South Carolina and Maryland. The series is of moderate extent.

MLRA OFFICE RESPONSIBLE: Raleigh, North Carolina

SERIES ESTABLISHED: City of Virginia Beach, Virginia, 1979. The name is from a small comm~ty.

REMARKS: Acredale soils have been included with Bladen and Roanoke soils in past mapping.

ADDITIONAL DATA: Virginia Polytechnic Institute and State University soil survey lab data shows the typical pedon of the Acredale series to have a base saturation of 74.67 percent at 50 inches below the top of the argillic. The particle-size control section has 26 percent clay, 55 percent silt, and 9 percent sand that is coarser than very fmc sand as a weighted average, with 76 percent quartz and 20 percent weatherable minerals, mainly feldspar and mica, in the 20 to 2,000 micron fraction.

Sample Numbers: S77VA76-49-(1-6), S73VA76-3-(1-7), S75VA76-23-(1-6), S75VA-76-20-(1-5), S77VA-76-66-(1-7), S75-VA-76-29-(1-6), S78VA-76-62-(1-5), S73VA-76-1-(1-7).

TABULAR SERIES DATA:

SOI-5	Soil Name	Slope	Airtemp	FrFr/Seas	Precip	Elevation
VA0160	ACREDALE	0- 2	59- 65	190-260	40- 56	1- 100

SOI-5 FloodL FloodH Watertable Kind Months Bedrock Hardness VA0160 NONE RARE

SOI-5 Depth Texture 3-Inch No-10 Clay% -CEC- VA0160 0- 7 SILL

SOI-5	Depth	-pH-	O.M.	Salin	Permeab	Shnk-Swll
VA0160	0- 7	3.6- 5.5	2.-8.	0- 0	0,6- 2.0	LOW
VA0160	7-15	3.6- 5.5	.5-1.	0- 0	0.6- 2.0	LOW
VA0160	15-43	4.5- 7.3	0.-.5	0- 0	0.06- 0.2	MODERATE
VA0160	43-66	4.5- 7.3	0.-.5	0- 0	2.0- 20	LOW

National Cooperative Soil Survey
U.S.A.

LOCATION COTAC0 KY+TN VA WV

Established Series
Rev. JHN:CWH:JMR
01/2001

COTACO SERIES

The Cotaco series consists of very deep, moderately well or somewhat poorly drained, moderately permeable soils formed in loamy sediments of acid sandstone, siltstone, and shale origin. These soils are on foot slopes, colluvial fans, and low stream terraces. The average annual temperature is about 55 degrees F, and the average annual precipitation is about 48 inches. Slopes range from 0 to 25 percent.

TAXONOMIC CLASS: Fine-loamy, mixed, active, mesic Aquic Hapludults

TYPICAL PEDON: Cotaco loam--cultivated--on a smooth concave 1 percent slope. (Colors are for moist soil.)

Ap--0 to 10 inches; dark grayish brown (10YR 4/2) loam; weak fine granular structure; very friable; many fine roots; about 2 percent pebbles; slightly acid; abrupt smooth boundary. (5 to 12 inches thick)

BA--!0 to 16 inches; yellowish brown (10YR 5/4) ped interiors and brown (10YR 5/3) ped faces; sandy clay loam; common medium faint strong brown (7.SYR 5/6) mottles; weak medium sabangular blocky structure; friable; many fmc roots; about 5 percent by volume of pebbles; few patchy clay films on pecks; many fine pores; slightly acid; gradual smooth boundary. (0 to 10 inches thick)

Btl--16 to 23 inches; yellowish brown(10YR 5/4) gravelly sandy clay loam; common medium distinct light brownish gray (2.SYR 6/2), dark brown (7. SYR 4/4), and yellowish brown (10YR 5/8) mottles; weak medium subangular blocky structure; friable; thin clay films on peds; 15 percent by volume sandstone and shale pebbles and thin flat fragments; strongly acid; gradual smooth boundary. (5 to 25 inches thick)

Bt2-23 to 41 inches; mottled grayish brown (2.5Y 5/2), yellowish brown (10YR 5/8), and dark brown (7.5YR 4/4) gravelly clay loam; moderate medium subangular blocky structure; friable; thin clay films; about 30 percent by volume pebbles and dark reddish brown concretions; strongly acid; gradual smooth bOundary. (0 to 3.0 inches thick)

C1--41 to 46 inches; yellowish brown (10YR 5/4) gravelly clay loam; many me, dim distinct dark brown (7.5YR 4/4) and light brownish gray (10YR 6/2) mottles; massive; friable; about 40 percent by volume pebbles and dark concretions; strongly acid; gradual smooth boundary. (0 to 20 inches thick)

C2--46 to 66 inches; mottled yellowish brown (10YR 5/6), gray (10YR 6/1), and dark brown (7.SYR 4/4) sandy clay loam; massive; slightly sticky; about 5 percent by volume pebbles; strongly acid.

TYPE LOCATION: Crreenup County, Kentucky; on a tributary of East Fork Creek 1/4 mile east of KY 503, and 1 1/4 mile south of junction of KY 207 and KY 503.

RANGE IN CHARACTERISTICS: The solum thickness ranges from 30 to 60 inches, and depth to bedrock is more than 60 inches. Fragments of sandstone, shale, or siltstone range from 2 to 35 percent in the solum, and from 2 to 50 percent in the C horizon. Unless limed, the reaction ranges from strongly acid to extremely acid.

The A horizon has hue of 10YR, value of 4 or 6, and chroma of 2 to 4. It is loam, silt loam, or fine sandy loam, and the gravelly analogues.

The Bt horizon has hue of 2.5Y to 5Y1L value of 4 to 6, and chroma of 3 to 8. It is silt loam, loam, clay loam, or sandy clay loam, and the gravelly analogues. Mottles are in shades of gray, brown, and red.

Some pedons have BC horizons with colors like the Bt horizon, and others have lower Bt or BC horizons that are mottled or with matrix colors in shades of gray. A few pedons have 2B horizons in the lower solum or 2C horizons.

The C horizon has hue of 7.5YR to 2.5Y, value of 4 through 8, and chroma of 0 through 8, or mottled in these colors without dominant matrix hue. The texture is silt loam, loam, clay loam, sandy clay loam, and the gravelly analogues. Some pedons are stratified.

COMPETING SERIES: These are Adelphia, Blairton, Cana, De!anco, Dillard, Mattapex, Tuscarawas, and Wharton series in the same family. Adelptna ~"/'-~'-d~oI~-~l sm s~~--~-'~conite. Blair/on soils ' contain more silt, and have 30 to 70 percent shale fragments in the lower solum. Cana and Tuscarawas soils contain more silt and less sand, and in addition, Cana soils have an upper solum developed in loess. Delanco soils contain a noticeable amount of mica in the solum, and have 2B and 2C horizons formed in residuum from mudstone. Dillard soils contain a noticeable amount of mica in the solum and have 2B horizons in shades of gray that are clay or clay loam. Mattapex soils are formed in coastal plains material, lack fragments of sandstone and siltstone in the solum, and have 2C horizons. Wharton soils have rippable shale at 40 to 72 inches, and typically have silt loam or silty clay loam fine earth textures in the solum.

GEOGRAPItIC SETTING: Foot slopes, colluvial fans, and Iow stream terraces with slopes of 0 to 25 percent. The regolith is alluvium of acid sandstone, siltstone, and shale origin. Near the type location, the average annual precipitation is 42 to 54 inches, and average annual ak temperature is 47 to 57 degrees F.

GEOGRAPItICALL¥ ASSOCIATED SOILS: These are Allegheny. and Monongahela series on stream terraces, Pope and Stendal series on flood plains, and Dekalb, Jefferson, and Shelocta series of the surrounding uplands. A~i~'~ny, Jefferson, and Shelocta so~-6lI~l-~ck gray mottles in the upper 24 inches of the argillic horizon. Monongahela soils have fragipans. Dekalb, Pope, and Stendal soils lack argillic horizons.

DRAINAGE AND PERMEABILITY: Moderately well or somewhat poorly drained; medium runoff; moderate permeability. Seep spots are common.

USE AND VEGETATION: Largely used for crops, principally eom, burley, tobacco, small grains, truck, fruit, sorghum, and hay or pasture. Native forest has oak, hickory, elm, beech, sourwood, blackgum, and yellow-poplar as the dominant species.

DISTRIBUTION AND EXTENT: The Cumberland-Allegheny Plateau in Kentucky, Tennessee, and Virginia. Extent is moderate.

MLRA OFFICE RESPONSIBLE: Morgantown, West Virginia

SERIES ESTABLISHED: Jackson County, Alabama; 1944.

REMARKS: Diagnostic horizons and features recognized in this pedon are:

Ochric epipedon - The zone from the surface of the soil to a depth of approximately 10 inches (Ap horizon)

Argillic horizon - The zone from approximately 16 to 41 inches (Btl, Bt2 horizons)

National Cooperative Soil Survey
U.S.A.

LOCATION DOGUE VA+GA NC

Established Series
Rev. JHW-EPE-JAK
06/2000

DOGUE SERIES

MLRA(s): 133A, 136, 153A, 153B
MLRA Office Responsible: Raleigh, North Carolina
Depth Class: Very deep
Drainage Class: Moderately well drained
Permeability: Moderately slow
Surface Runoff'. Slow to rapid
Parent Material: Clayey marine and fluvial sediments
Slope: 0 to 15 percent
Mean Annual Air Temperature (type location): 57 degrees F.
Mean Annual Precipitation (type location): 39.5 inches .'

TAXONOMIC CLASS: Fine, mixed, semiactive, thermic Aquic Hapludults

TYPICAL PEDON: Dogue loam (Colors are for moist soil.)

A--0 to 4 inches; dark grayish brown (2.5Y 4/2) loam; moderate fine granular structure; very friable; many fine roots; few fine pores; strongly acid; clear smooth boundary. (2 to 4 inches thick)

E--4 to 10 inches; light olive brown (2.5Y 5/4) loam; weak fine subangular blocky structttre; fi'iable; many fine andmedium roots;'few fine pores; strongly acid; clear smooth boundary. (0 to 8 inches thick)

Btl--10 to 14 inches; yellowish brown (10yR 5/6) clay loam; weak medium subangular blocky structure; firm; moderately sticky, moderately plastic; common fine room; few fine pores; few faint clay films on faces of peds; few f'me flakes of mica; very strongly acid; clear smooth boundary.

Bt2--14 to 24 inches; yellowish brown (10YR 5/6) clay; moderate fmc angular blocky structure; firm; moderately sticky, moderately plastic; common fine roots; few fine pores; common distinct clay films on faces ofpeds; few f'me flakes of mica; strongly acid; clear smooth boundary.

Bt3--24 to 34 inches; yellowish brown (10YR 5/6) clay loam; moderate medium angular blocky · structure; fu'm, moderately sticky, moderately plastic; few f'me roots; common medium faint'strong brown (7.5YR 5/6) soft masses of iron accumulation and common medium prominent light brownish gray (10YR 6/2) and gray (10YR 5/1) iron depletions; common distinct clay films on faces ofpeds; common fine flakes of mica; very strongly acid; clear smooth boundary.

Bt4--34 to 47 inches; multicolored strong brown (7.SYR 5/8), gray (10YR 5/1), and red (2.5YR 4/6) clay loam; moderate fine angular blocky structure; rum; moderately sticky, moderately plastic; few f'me roots; few gray (10YR 5/1) clay films on faces ofpeds; common fmc flakes of mica; very strongly acid; gradual smooth boundary. (combined thickness of the Bt horizon is 25 to 50 inches)

2C--47 to 65 inches; strong brown (7.5YR 5/6) stratified loamy fine sa.ad and sandy loam; massive; very fi'iable; many medium prominent light brownish gray (10YR 6/2) iron depletions; common fmc flakes of mica; very strongly acid.

TYPE LOCATION: King George County, Virginia, 30 yards west of VA-631, 75 yards north of VA-607.

RANGE IN CHARACTERISTICS:
Solum Thickness: 40 to 60 inches
Depth to Bedrock: Greater than 60 inches
Depth to Seasonal High Water Table: 18 to 36 inches, January to March
Soil Reaction: extremely acid to strongly acid, except where limed
Other Features: Rock fragments, usually rounded quartzite gravel, make up 0 to 15 percent of the solana and 0 to 25 percem of the C horizon. Few to common flakes of mica and grains of feldspar are in the B and C horizons. Average clay content in the particle size control section is 35 to 50 percent, and silt content is less than 30 percent, or silt plus very fine sand is less than 40 percent

A or Ap horizon:
Color--hue of 10YR or 2.5Y, value of 3to 6, and chroma of 2 to 4. Where value is 3, surface layer is less than 6 inches thick.
Texture--loam, silt loam, fine sandy loam, very fine sandy loam, or sandy loam

E horizon (if it occurs):
Color--hue of 10YR or 2.5Y, value of 4 through 7, and c~oma of 3 through 6
Texture--sandy loam, fine sandy loam, very fine sandy loam, loam, or silt loam

BE or BA horizon (it if occurs):
Color--hue of 7.5YR through or 2.5Y, value of 4 through 7, and ehroma of 4 through 8
Texture--clay loam, sandy clay loam, or loam

Bt horizon:
Color--hue of 7.5YR to 2.5Y, value of 4 to 7, and chroma of 3 to 8
Texture--is clay loam, sandy clay loam, sandy clay, or clay
Redox~morphic feamres--~rOn masses m shades of brown, yellow, or red and iron depletions in shades of brown, olive, or gray

Btg horizon (if it occurs):
Color--hue of 7.5YR to 2.5Y or is neutral, value of 4 to 7, and chroma of 0 to 2
Texture--is clay loam, sandy clay loam, sandy clay, or clay
Redoximorphic features--iron masses m shades of brown, yellow, or red and iron depletions in shades of brown, olive, or gray

BC or CB horizon (if it occurs):
Color--hue of 7.5YR to 2.5Y, value of 4 to 7, and chroma of 3 to 8
Texture--sandy loam, sandy clay loam, clay loara, or sandy clay
Redoximorphie features--iron masses m shades of brown, yellow, or red and iron depletions in shades of brown, olive, or gray

The BCg or CBg horizon (if it occurs):
Color--hue of 7.5YR to 2.5Y or is neutral, value of 4 to 7, and chroma of 0 to 2
Texture--sandy loam, sandy clay loam, clay loam, or sandy clay
Redoximorphic features--iron masses m shades of brown, yellow, or red and iron depletions in shades of brown, olive, or gray

C or 2C horizon (if it occurs):
Color--has hue of 7.5YR to 2.5Y, value of 4 to 7, and chroma of 3 to 8
Texture--typically stratified and ranges from sand through sandy clay loam in the fmc earth fraction
Redoximorphic features--iron masses m shades of brown, yellow, or red and iron depletions in shades of brown, olive, or gray

Cg or 2Cg horizon (if it occurs):
Color--hue of 7.5YR to 2.5Y or is neutral, value of 4 to 7, and chroma of 0 to 2
Texture--typically stratified and ranges from sand through sandy clay loam in the frae earth fraction
Redoximorphic features--iron masses m shades of brown, yellow, or red and iron depletions in shades of

brown, olive, or gray

COMPETING SERIES:
Annemaine soils--have dominant hue redder than 7.SYR
Beason soils--soils have more than 30 percent silt in the particle size control section
El-d-~'[ls--have a lithic contact at a depth of 20 to 40 inches
E~-~ven soils--soils have more than 30 percent silt in the particle size control section
~-~--~noor soils--have very slow permeability in the Bt horizon
Eulonia soils--have a dominantly gray lower Bt horizon and low shrink-swell potential
•soils--have a perched water table
soils--have a high shrink-swell potential in the lower part of the Bt horizon
•_~aSOils--have a solum 20 to 40 inches thick
soils--have a perched water table and fragments of ironstone in the Bt horizon
Nemours soils--have dominant hue redder than 7.5YR
Nevarc soils--have a perched water table and are generally on steeper slopes
~ soils--have dominant hue redder than 7.5YR
Pe~k soils--have a high shrink-swell potential in the lower part of the Bt horizon, particle size control section has more than 30 percent silt or more than 40 percent silt plus very frae sand and aluminum saturation on the exchange complex is commonly greater than 50 percent
Prosperity--has paralitkic contact within a depth of 60 inches
Sacul soils--have dominant hue redder than 7.5YR
~ soils--depth to bedrock ranges from 20 to 40 inches
Vtmta soils--have a solum 20 to 40 inches thick
Wo-----6-~ever soils--soils have more than 30 percent silt in the particle size control section

GEOGRAPHIC SETTING:
Landscape: Piedmont and Coastal Plain
Landform: Stream and Marine Terraces
Elevation: Less than 10 to 1100 feet above mean sea level
Parent Material: Loamy'marine and fluvial sediments
Mean Annual Air Temperature: 57 to 66 degrees
Mean Annual Precipitation: 38 to 54 inches
Frost Free Period: 175 to 260 days

GEOGRAPHICALLY ASSOCIATED SOILS:
Altavista soils--moderately well drained soils (seasonal high water table 18 to 30 inches) in frae-loamy family on similar landscapes
Augusta soils--Somewhat poor!y drained soils (seasonal high water table 12 to 18 inches) in f'me-loamy family on similar landscapes
~ soils--well drained soils (seasonal high water table 48 to 72 inches) in coarse-loamy family on slightly higher landscapes '
Conetoe soils--well drained soils (seasonal high water table below 72 inches) in loamy family on slightly higher landscapes
Dragston soils--somewhat poorly drained soils (seasonal high water table 0 to 12 inches) in coarse-loamy family on similar landscapes
Masada soils--well drained soils (seasonal high water table below 72 inches) on slightly higher ~pes
Munden soils--moderately well drained soils (seasonal high water table 18 to 30 inches) in coarse-loamy family on similar landscapes
Roanoke soils--poorly drained soils (seasonal high water table 0 to 12 inches) on flats and in depressions
State soils--well drained soils (seasonal high water table 48 to 72 inches) in f'me-loamy family on higher ~capes
Tarboro soils--somewhat excessively drained soils (seasonal high water table is below 6 feet) with sandy textures throughout on slightly higher landscapes

Wahoo soils--somewhat poorly drained soils (seasonal high water table 12 to 18 inches) on similar
~apes
Wickham soils--well drained soils (seasonal high water table is below 6 feet) in frae-loamy family on

slightly higher landscapes
- soils--moderately well drakned soils (seasonal high water table 18 to 3 6 inches) in fine-silty n similar landscapes

DRAINAGE AND PERMEABILITY:
Agricultural Drainage Class: Moderately well drained
Permeability: moderately slow
Flooding: soils on low sla'eam terraces are subject to rare flooding. Dogue soils on second bottoms are. subject to occasional flooding

USE AND VEGETATION:
Major Uses: Mostly cultivated
Dominant Vegetation: Where cultivated--eom, small grain, soybeans, iobaceo, peanuts, and track crops. Where wooded-- mixed hardwoods and pines

DISTRIBUTION AND EXTENT:
Distribution: Virginia, North Carolina, Georgia, and possibly South Carolina and Maryland
Extent: Moderate

MLRA OFFICE RESPONSIBLE: Raleigh, North Carolina

SERIES ESTABLISHED: King George County, Virginia, 1970.

REMARKS: Diagnostic horizons and features recognized in this pedon are:
Ochric epipedon - the zone from the surface to 10 inches (A and E horizons).
Argillic horizon - The zone from 10 to 47 inches (Bt horizon).
Aquic conditions - 2 cb. roma or less iron depletions within the upper 24 inches of the argillic horizon.

SIR = VA0082

MLRA = 133A, 136, 153A, 153B
REVISED = 2/13/96, DTA
ADDITIONAL DATA:
TABULAR SERIES DATA:

SOI-5	Soil Name	Slope	Airtemp	FrFr/Seas	Precip	Elevation
VA0082	DOGUE	0- 15	57- 65	175-260	38- 54	10- 750

SOI-5	FloodL	FloodH	Watertable	Kind	Months	Bedrock	HardneSs
VA0082	NONE	OCCAS	1.5-3.0	APPARENT	JAN-MAR	60-60	

SOI-5	Depth	Texture	3-Inch	No-10	Clay%	-CEC-
VA0082	0-10	L SIL VFSL	0- 0	75-100	5-15	3- 10
VA0082	0-10	FSL SL	0- 0	75-100	5-10	2- 6
VA0082	10-47	CL C SC	0- 0	75-100	35-50	8- 20
VA0082	47-65	SR S SCL	0- 0	60-100	5-30	1- 6

SOI-5	Depth	-pH-	O.M.	Salin	Permeab	Shnk-Swll
VA0082	0-10	3.5- 5.5	.5-1.	0- 0	0.6- 2.0	LOW
VA0082	0-10	3.5- 5.5	.5-1.	0- 0	2.0- 6.0	LOW
VA0082	10-47	3.5- 5.5	0.-.5	0- 0	0.2- 0.6	MODERATE
VA0082	47-65	3.5- 5.5	0.-.5	0- 0	0.6- 6.0	LOW

National Cooperative Soil Survey

U.S.A.

LOCATION DRAGSTON '- VA+NC

Established Series
Rev. RLH-WJE-MHC
04/2000

DRAGSTON SERIES

MLRA(s): 133A 153A; 153B
MLRA Office Responsible: Raleigh, North Carolina
Depth Class: Very deep
Drainage Class: Somewhat poorly drained
Permeability: Moderately rapid
Surface Runoff: slow
Parent Material: loamy marine and fluvial sedimems
Slope: 0 to 2 percent
Mean Annual Air Temperature (type location): 61 degrees F.
Mean Annual Precipitation (type location): 42 inches

TAXONOMIC CLASS: Coarse-loamy, mixed, semiactive, thermie Aerie Endoaquults

T.vPICAL PEDON: Dragston fine sandy loam - cultivated. (Colors are for moist soil.)

Ap--0 to 9 inches; dark grayish brown (10YR 4/2) fine sandy loam; weak medium granular structure; very friable; many fine roots; many fine pores; strongly acid; abrupt smooth boundary. (0 to 12 inches thick)

Bt--9 to 17 inches; light olive brown (2.5Y 5/4) frae sandy 10am; weak medium subangular blocky structure; friable, slightly sticky; few fmc pores; common medium prominent yellowish brown (10YR 5/8) soft iron masses and few distinct grayish brown (2.5Y 5/2) iron depletions; few faint clay films on faces of peds and clay bridging.between sand grains; very strongly acid; clear wavy boundary. (0 to 14 inches thick)

Btg--17 to 28 inches; grayish brown (2.5Y 5/2) fine sandy loam; weak medium subangular blocky structure; friable, slightly sticky; common medium prominem yellowish brown (10YR 5/8) soft iron masses; few faint clay films on faces ofpeds and clay bridging between sand grains; very strongly acid; gradual wavy boundary. (6 to 25 inches thick)

BCg--28 to 37 inches; grayish brown (10YR 5/2) fine sandy loam; weak-very coarse subangular blocky structure; very friable, nonsticky, nonplastic; common medium prominent yellowish brown (10YR 5/6) soft iron masses; very strongly acid; gradual wavy boundary. (0 to 10 inches thick)

C--37 to 66 inches; brownish yellow (10YR 6/8) fmc sand; single grain; loose; few coarse prominent light brownish gray (10YR 6/2) iron depletions; very strongly acid.

TYPE LOCATION: City of Suffolk, Virginia; 1.07 miles north of imersection of VA-624 and VA-658 and 270 feet east of VA-624.

RANGE IN CHARACTERISTICS:
Solum Thickness: 25 to 50 inches
Depth to Bedrock: Greater than 60 inches
Devth to Seasonal High Water Table: 12 to 30 inches, No~,ember to April
Soil Reaction: very strongly acid or strongly acid in the A, E, BA, and BE horizons and upper Bt horizon unless limed, and very strongly acid to slightly acid in the lower Bt, BC, CB and C horizon

A or Ap horizon:
Color--hue of 10YR to 5Y, value of 2 to 5, and chroma of i to 4; where value is 3 the layer is less than 10 inches thick
Texture: loamy sand, loamy fine sand, sandy loam, frae sandy loam, or loam

E horizon (if it occurs):
Color--has hue of 10YR to 5Y, value of 4 to 7, and chroma of 1 to 4
Texture--loamy sand, loamy fine sand, sandy loam, fine sandy loam, or loam
Redoximorphic features--iron masses in shades of brown, yellow, or red and iron depletions m shades of brown or gray

BA or BE horizon (if it occurs):
Color--hue of 10YR to 5Y, value of 4 to 6, and chroma of 3 to 8
Texture--sandy loam, fmc sandy loam, or loam
Redoximorphic features--iron masses in shades of brown, yellow, or red and iron depletions m shades of brown or gray

Bt horizon:
Color--hue of 10YR to 5Y, value of 4 to 6, and chroma of 3 to 8
Texture--sandy loam, frae sandy loam, or loam; some pedons may have thin layers of sandy clay loam
Redoximorphic features--iron masses in shades of brown, yellow, or red and iron depletions m shades of brown or gray

Btg horizon (if it occurs):
Color--hue of 50YR to 5Y or is neutral, value of 4 to 6, and chroma of 0 to 2
Texture--sandy loam, fine sandy loam, or loam; some pedons may have thin layers of sandy clay loam
Redoximorphic features--iron masses in shades of brown, yellow, or red and iron depletions m shades of brown or gray

BC, BCg or CB, CBg horizon (if it occurs):
Color--hue of 10YR to 5Y or is neutral, value of 4 to 6, and chroma of 0 to
Texture--loamy sand, loamy fmc sand, sandy loam, or fine sandy loam.
Redoxirnorphic features--iron masses in shades of brown, yellow, or red and iron depletions m shades of brown or gray

C horizon (if it occurs):
Color--has hue of 10YR to 5Y, value of 4 to 7, and chroma of 3 to 8
Texture--sand, fine sand, loamy sand, loamy fine sand, sandy loam, or fine sandy loam or is stratified
Redoximorphic.features--iron masses in shades of brown, yellow, or red and iron depletions m shades of brown or gray

Cg horizon (if it occurs)
Color--10YR to 5BG or is neutral,' value of 4 to 7, and chroma of 0 to 2
Texture--sand, fine sand, loamy sand, loamy frae sand, sandy loam, or fine sandy loam or is stratified
Redoximorphic features--iron masses in shades of brown, yellow, or red and iron depletions in shades of brown or gray

COMPETING SERIES: There are no other series in the same family

GEOGRAPIIIC SETTING:
Landscape: Coastal Plain
Landform: Marine Terrace
Elevation: Less than 25 feet above mean sea level
Parent Material: loamy marine or fluvial sediments

Mean Annual Air Temperature: 59 to 65 degrees
Mean Annual Precipitation: 40 to 48 inches
Frost Free Period: 190 to 240 days

GEOGRAPHICALLY ASSOCIATED SOILS:
Altavista soils--moderately well drained soils (seasonal high water table 18 to 30 inches) in fine-loamy family on slightly higher landscapes
• soils--somewhat poorly drained soils (seasonal high water table 12 to 18 inches) in frae-loamy n similar landscapes
•soils--well drained soils (seasonal high water table 48 to 72 inches) in on higher landscapes
oe soils--well drained soils (seasonal high water.table below 72 inches) in loamy family on higher ~pes
s~ySOils--moderately well drained soils (Seasonal high water table 18 to 30 inches) in fine family on higher landscapes
Munden soils--moderately well drained soils (seasonal high water table 18 to 30 inches) slightly higher ~es
Nimmo soils--poorly drained soils (seasonal high water table 0 to 12 inches) on flats and in slight ~ions
Roanoke soils--poorly drained soils (seasonal high water table 0 to 12 inches) in fine family on fiats and in slight depressions
State soils--well drained soils (seasonal high water table 48 to 72 inches) in fine-loamy family higher ~capes
Tarboro soils--somewhat excessively drained soils (seasonal high water table is below 6 feet) with sandy textures throughout on higher landscapes
Tetotum soils--moderately well drained soils (seasonal high water table 18 to 30 inches) in frae-loamy family on slightly higher landscapes
Tomofle¥ soils-pc-)fly drained soils (seasonal high water table 0 to 12 inches) in fine-loamy family on flats and in slight depressions
Wahee soils--somewhat poorly drained soils (seasonal high water table 12 to 18 inches) in frae family on s-'-m-m-m-m-m-m-m-m~ landscapes

DRAINAGE AND PERMEABILITY:
Agricultural Drainage Class: Somewhat poorly drained
?ermeability: moderately rapid

USE AND VEGETATION:
Major Uses: Mostly cultivated
Dominant Vegetation: Where cultivated--corn, soybeans, peanuts, small grain, track crops, and pasture. Where wooded--loblolly pine, sweetgurn, yellow poplar, water oak, southern red oak, and red maple; understory plants include American holly, flowering dogwood, sassafras, greenbrier, giant cane and inkberry (bitter gallberry)

DISTRIBUTION AND EXTENT:
Distribution: Virginia, North. Carolina, and Maryland
Extent: MOderate

lVlLRA OFFICE RESPONSIBLE: Raleigh, North Carolina

SERIES ESTABLISHED: Princess Anne County, Virginia, 1939 (presently City of Virginia Beach).

REMARKS: Revised to Endoaquults, 1997
Diagnostic horizons and features recognized in this pedon are:
a. Ochric epipedon - the zone from 0 to 9 inches (Ap horizon).

b. Argillic horizon - the zone from 9 to 28 inches (Bt and Btg horizons).

SIR = YA00g3

MLRA= 133A, 153A, 153B

REVISED = 9/8/97 RL¥

ADDITIONAL DATA: Particle-size data from the typical pedon is available from Virginia Polytechnic Institute and State University soil survey laboratory. Lab numbers 74-255 through 74-260.

TABULAR SERIES DATA:
SOI-5 Soil Name Slope Airtemp FrFr/Seas Precip Elevation
VA0083 DRAGSTON 0-2 59-65 190-240 40-48 5-200

SOI-5	FloodL	Watertable	Kind	Months	Bedrock
VA0083	NONE	1.0-2.5	APPARENT	NOV-APR	>60

SOI-5	Depth	Texture	3-Inch	No-10	Clay%	-CEC-
VA0083	0-9	FSL SL L	0-0	95-100	4-12	
VA0083	0-9	LFS LS	0-0	95-100	2-10	
VA0083	9-37	FSL SL L	0-0	95-100	10-18	
VA0083	37-66	S LS FSL	0-0	85-100	2-12	

SOI-5	Depth	-pH-	O.M.	Permeab	Shnk-Swll
VA0083	0-9	4.5-5.5	1.-2.	2.0-6.0	LOW
VA0083	0-9	4.5-5.5	.5-1.	6.0-20	LOW
VA0083	· 9-37	4.5-5.5	0.-.5	2.0-6.0	LOW
VA0083	37-66	4.5-6.5	0.-.5	6.0-20	LOW

National Cooperative Soil Survey
U.S.A.

LOCATION EMPORIA VA+AL NC SC

Established Series
Rev. RLH-WJE-MHC
07/1999

EMPORIA SERIES

Soils of the Emporia series are very deep and well drained with moderately slow or slow permeability. They formed in moderately f'me-textared stratified fluvial and marine sediments on the upper Coastal Plain. Slopes commonly are 1 to 6 percent, but range from 0 to 50 percent. Mean annn_al temperature is about 62 degree F and mean armual precipitation is about 48 inches.

TAXONOMIC CLASS: Fine-loamy, siliceous, subactive, thermie Typic Hapludults

TYPICAL PEI}ON: Emporia loamy fmc sand--on a 3 percent slope in a cultivated field. (Colors are for moist soil.)

Ap--0 to 6 inches; pale brown (10YR 6/3) loamy fine sand; weak fine granular structure; very friable; many f'me medium and coarse roots; strongly acid; clear smooth boundary. (4 to 12 inches thick)

E--6 to 15 inches; pale brown (10YR 6/3) fine sandy loam; weak fmc granular structure; very friable; common fine and medium roo:,; strongly acid; gradual smooth boundary. (0 to 15 inches thick)

Btl,-15 to 32 inches; yellowish brown (10YR 5/6) sandy clay 10am; weak medium subangular blocky' structure; friable, slightly sticky, slightly plastic; few fine and medium roots; few distinct clay films on faces ofpeds; many sand grains bridged and coated with clay; few medium distinct yellowish red (5YR 5/8) masses of iron accumulation on faces ofpeds; strongly acid; diffuse smooth boundary.

Bt2--32 to 44 inches; yellowish brown (10YR 5/6) clay loam; weak very thick platy structure parting to moderate medium subangular blocky; friable, sticky, slightly plastic; few frae and medium roots; many . distinct clay films on faces ofpeds; many medium prominent red (2.5YR 4/8) masses of iron accumulation on faces of peds; very strongly acid; diffuse smooth boundary.

Bt3--44 to 57 inches; yellowish brown (10YR 5/6) sandy clay loam; weak very thick platy structure parting to weak medium subangular blocky; friable, firm in place, slightly sticky, slightly plastic; common distinct clay films on faces ofpeds; many distinct light gray (10YR 7/1) iron depletions in the matrix and red (2.SYR 5/8) masses of iron accumulation on faces of peds;very strongly acid; diffuse smooth boundary. (Combined thickness of the Bt horizon is 20 to 58 inches.)

C--57 to 70 inches; yellow (2.5Y 7/6), light gray (10YR 7/1), and reddish brown (2.SYR 5/4) sandy clay loam; massive; friable, f'rrm in place, slightly sticky, slightly plastic; light gray colors are in areas of iron depletion; yellow colors are.in areas of iron accumulation; very strongly acid.

TYPE LOCATION: Greensville County, Virginia; 2.2 miles south of Skippers, about 2,500 feet west of the junction of U.S. 301 and VA-642 and 100 feet north of YA-642.

RANGE IN CI-IARACTERISTICS: Solum thickness commonly is 40 to 60 inches, but ranges from 40 to 75 inches. Depth to bedrock is more than 6 feet. Gravel size rock f~agrnents ranges from 0 to 35 percent in the solum and 0 to 60 percent in the C horizon. Some pedons have a lithologic discontinuity generally below 40 inches. Some part of the Bt or BC horizon of most pedons commonly has firm or very firm consistence in place. Exchangeable aluminum is less than 6 meq/100 grams of soil in the solum. Mica flakes range from none'to common, and are present only in some pedons. The soil is very strongly acid through moderately acid, unless limed.

The Ap horizon, where present, has hue of 10YR or 2.5Y, value of 4 through 6, and chroma of 2 through 4. It is loamy sand, loamy fine sand, sandy loam, fmc sandy loam, or loam in the fine-earth fraction.

The A horizon, where present, has hue of 10YR or 2.5Y, 'value of 2 through 6, and chroma of 2 through 4. It is loamy sand, loamy fine sand, sandy loam, fine sandy loam, or loam in the fmc-earth fraction.

The E horizon, where present, has hue of 10YR or 2.5Y, value of 5 through 7, and chroma of 3 to 6. It is loamy sand, loamy frae sand, sandy loam, fine sandy loam, or loam in the fmc-earth fraction.

The BA or BE horizon, where present, has hue of 7.5YR through 2.5Y, value of 5 through 7, and chroma of 3 through 6. Texture is sandy loam, frae sandy loam, or loam in the fine-earth fraction.

The upper part of the Bt horizon has hue of 5YR through 10YR, value of 4 through 7, and chroma of 3 through $. The lower part of the Bt horizon has hue of 5YR through 2.5Y, value of 4 through 7, and chroma of 3 through 8, or it is multicolored without dominant matrix hue. Iron depletions commonly are below a depth of 36 inches. The Bt horizon is sandy loam, fine sandy loam, loam~ sandy clay loam, or clay loam. The lower part of the Bt horizon ranges to sandy clay or clay in some pedons.

The Btg horizon, where present, is neutral or has hue of 5YR through 2.5Y, value of 4 through 6, and chroma of 0 through 2. It is sandy loam, fmc sandy loam, loam, sandy clay loam, or clay loam in the fmc-earth ~action. It ranges to sandy clay or clay in some pedons.

The BC or CB horizon, where present, has hue of 2.SYK through 2.5Y, value of 4 through 6, and chroma of 3 through 8, or it is multicolored without dominant matrix hue. It is coarse sandy loam, sandy loam, fine sandy loam, loam, sandy .. lay loam, or clay loam in the fmc-earth fraction. It ranges to sandy clay or clay in some pedons.

The BCg or CBg horizon, where present, is neutral or has hue of 2.5YR through 2.5Y, value of 4 through 6, and chroma of 0 through 2. It is coarse sandy loam, sandy loam, fine sandy loam, loam, sandy clay loam, or clayloam in the fmc-earth.fraction. It ranges to sandy clay or clay in some pedons:

The C horizon, where present, has hue of 2.SYR through 5Y, value of 3 through 8, and chroma of 3 through 8, or it is multicolored without dominant matrix hue. Most pedons are variegated with iron depletions and accumulations. The C horizon ranges from sandy'loam through clay in the fine-earth fraction.

The Cg horizon, where present, is neutral or has hue of 5YR through 5Y, value 'of 3 through 8, and cb_roma of 0 through 2. It is sandy loam through clay in ~e fmc-earth fraction.

COMPETING SERIES: (This sectionnot checked this date:activity class added) These are the Apison, _Cahaba, Durham, Euharlee, Granville, Hartsells, Kempsville, Linker, Nauvoo, Oktaha, ~ Pirum, Sipsey, Smithdale, Spa&a, Stringtown, and Suffolk series. Ap~son, Hartsells, Linker and S~psey soils have bedrock within 20 to 40 inches of the soil sm~ace. Cahaba, Durham, Euharlee, Kempsville, Spadra, Smithdale, and Suffolk soils do not have iron depletions with chroma of 2 or less indicative of wetness. within the upper 50 inches of the soil. Granville soils have 6 to 13 meq. of exchangeable aluminum per 100 grams of soil. Nauvoo soils have a paralithic contact within 40 to 60 inches of the soil surface. Oktaha soils have a moisture deficit of more than -2 inches per year. Olla soils have friable consistence. (in place) in the lower part of the solum, and in addition do not have a water table above 6 feet and have moderate permeability. Pirum soils contain sandstone or shale fragments and have bedrock within 22 to 50 inches of the soil surface.

GEOGRAPItlC SETTING: Emporia soils are on uplands, short choppy slopes, and ridges in nearly level to very steep landscapes of the upper Atlantic Coastal Plain. Dominant slopes· are 1 to 6 percent, but range from 0 to 50 percent. These soils formed in stratified fluvial and marine sediments. Mean annual precipitation is about 48 inches, and mean annual temperature ranges from 59 to 62 degrees F.

GEOGRAPHICALLY ASSOCIATED SOILS: In addition to the competing Kempsville and Suffolk soils, these are the Bourne, Craven, Goldsboro, Lynchburg, Norfolk, Orangeburg, Roanoke, and Wahee ,s,~i~l~ ~.m ~e ,C.o, as~t~. P,--Y,~, .an~~le~..Fluvanna, Georgev~~mdon, and Wedowee soils al-'6'~-~e ~me otme t'ieamont. Bourne soils have a fragipan. Craven, Roanoke, and Wahee soils have a clayey particle-size control section. Goldsboro, Lynchburg, Norfolk, and Orangeburg soils have clay distribution that does not decrease by more than 20 percent of the maximum within 60 inches of the surface. Cullen, Fluv, nna, Georgeville, Hemdon, and Wedowee soils have a clayey particle- size control section and are associated with Emporia soils along the "fall line" where the Piedmont and Coastal Plain merge.

DRAINAGE AND PERMEABILITY: Well drained; slow to very rapid runoff; moderate or moderately slow permeability in the upper part of the subsoil and moderately slow or slow permeability in the lower part of the subsoil. A perched seasonal high water table is at a depth of 3 to 4 1/2 feet from November through April of most years.

USE AND VEGETATION: Most of the acreage is used for row crops. Principal crops are peanuts, soybeans, cotton, corn, and tobacco. Some areas are forested. Principal trees in forested areas include loblolly pine, Virginia pine, oaks, hickory, sweet gum, and maple.

DISTRIBUTION AND EXTENT: Atlantic Coastal Plain in Vixginia, North Carolina, South Carolina, and possibly in Alabama and Georgia. The series is extensive.

MLRA OFFICE RESPONSIBLE: Raleigh, North Carolina

SERIES ESTABLISHED: Gloucester County, Virginia, 1978.

REMARKS: Diagnostic horizons and other features recognized in this pedon are:
a. Ochric epipedon - the zone from 0 to 15 inches (Ap and E horizons), b. Argillic horizon - the zone between 15 and 57 inches (Bt horizon), c. Iron depletions .- the zone between 44 and 70 or more inches (BI3 and C horizons)

SIR = VA0102, VA0322 (GRAVELLY)
MLRA= 133A, 153A
REVISED = 7/9/96, MHC

TABULAR SERIES DATA:

SOI-5	Soil Name	Slope	,Airtemp	FrFr/Seas	Precip	Elevation
VA0102	EMPORIA	0- 50	59- 62	175-205	42- 52	20- 150
VA0322	EMPORIA	0- 50	59- 62	175-205	42- 52	20- 150

SOI-5 FloodL FloodH Watertable Kind Months Bedrock Hardness VA0102 NONE
VA0322 NONE 3.0-4.5 PERCHED NOV-APR 60-60

SOI-5	Depth	Texture	3-Inch	No-10	Clay%	-CEC-
VA0102	0-15 L FSL					
VA0102	0-15	LFS LS	0- 3	80-100	5-10	-
VA0102	15-32	SCL SL CL	0- 2	80-100	18-35	-
VA0102	32-57 '	SCL CL SC	0- 2	80-100	21-40	-
VA0102	57-70	SR SL C	0- 5	55-100	5-40	-
VA0322	0-15	GR-L GR-FSL GR-SL	0- 3	50-100	7-18	-
VA0322	0fl5	GR-LFS GR-LS	0- 3	50-100	5-10	-
VA0322	15-32	SCL SL CL	0- 2	50-100	18-35	-
VA0322	32-57	SCL CL SC	0- 2	50-100	21-40	-
VA0322	57-70	SR SL C	0- 5	50-100	5-40	-

SOI-5	Depth	-pH-	O.M.	Salin	Permeab	Shnk-Swll
VA0102	0-15	4.5- 6.0	.5-2.	0- 0	2.0- 6.0	LOW

VA0102 0-15	4.5- 6.0	.5-2.	0- 0	6.0- 20	LOW
VA0102 15-32	4.5- 6.0	0.-.5	0- 0	0.2- 2.0	LOW
VA0102 32-57	4.5- 6.0	0.-.5	0- 0	0.06- 0.6	MODERATE
VA0102 57-70	4.5- 6.0	0.-.5	0- 0	0.06- 2.0	MODERATE

VA0322	0-15	4.5- 6.0	.5-2.	0- 0	2.0- 6.0	LOW
VA0322	0-15	4.5- 6.0	.5-2.	0- 0	6.0- 20	LOW
VA0322	15-32	4.5- 6.0	0.-.5	0- 0	0.2- 2.0	LOW
VA0322	32-57	4.5- 6.0	0.-.5	0- 0	0.06- 0.6	MODERATE
VA0322	57-70	4.5- 6.0	0.-.5	0- 0	0.06- 2.0	MODERATE

ADDITIONAL DATA: Laboratory data from typical pedon by Virginia Polytechnic Institut

National Cooperative Soil Survey
U.S.A.

LOCATION FACE¥ILLE GA+AL FL MD NC SC VA

Established Series
Rev. LWF ,
01/98

FACEVILLE SERIES

The Faceville series consists of very deep, well drained, moderately permeable soils that formed in red clayey Coastal Plain sediments. These soils are on Coastal Plain uplands and have slopes ranging from 0 to 15 percent. Near the type location the mean annual temperature is 65 degrees F. and mean annual precipitation is 48 inches.

TAXONOMIC CLASS: Fine, kaolinitic, thermic'Typic Kandiudults

TYPICAL PEDON: Faceville fine sandy loam--southeast facing convex 1 percent slope. (Colors are for moist soil unless otherwise stated.)

Ap-0 to 5 inches; brown (10YR 4/3) fmc sandy loam; weak fmc granular structure; very friable; common fine and very fmc roots; strongly acid; abrupt smooth boundary. (4 to 10 inches thick)

BA--5 to 11 inches; yellowish red (5YR 5/6) sandy clay loam; weak fmc subangular blocky stmcture; friable; common fmc roots; few faint clay films on faces ofpeds; strongl~y acid; gradual wavy boundary. · (0 to 12 inches thick)

Btl--11 to 28 inches; yellowish red (5YR 5/6) sandy clay; moderate medium subangular blocky structure; friable; few fmc roots; common distinct clay. films on faces ofpeds;, strongly acid;,gradual. wavy boundary.

Bt2--28 to 34 inches; red (2.5YR 4/6) sandy clay; moderate medium subangular blocky structure; friable; common distinct clay films on faces ofpeds; strongly acid; gradual in-egular boundary.

Bt3--34 to 60 inches; red (2.SYR 4/6) sandy clay; few fine prominent strong brown (7.SYR 5/6) and yellowish brown (10YR 5/6) mottles; moderate medium subangular blocky structure; friable; common distinct and prominent clay films on faces ofpeds; strongly acid; diffuse irregular boundary.

Bt4--60 to 72 inches; coarsely mottled dark red (10R 3/6), yellowish brown (10YR 5/6) and very pale brown (10YR 7/3) sandy clay; strong medium subangular blocky structure; friable; few distinct and prominent clay films on faces ofpeds; strongly acid. (C}3mbined thickness of the Bt horizons is 43 to 61 inches or more)

TYPE LOCATION: Peach Counly, Georgia; 2.2 miles north on U. S. Highway 41 from intersection with Georgia Highway 96; 0.3 mile west on Lakeview road; north side of road. (Warner Robins SW GA. (1973) USGS Quadrangle, lat. 32 degrees, 34 minutes, 41 seconds N., and long. 83 degrees, 43 minutes, 28 seconds W.)

RANGE IN CItARACTERISTICS: The solum thickness is 65 inches or more. Reaction is very strongly acid or strongly acid except in surface horizons that have been limed and rarely moderately acid in the BA horizon and upper Bt horizon.

The A horizon has a hue of 10YR, 7.5YR, or 5YR, value of 4 or 5 and chroma of 2 through 8. It is · loamy sand, loamy frae sand, sandy loam, or fine sandy loam. Eroded phases have hue as red as 2.5YR and texture of sandy clay loam. Ironstone nodules in the A horizon range from none to about 11 percent and 3 to 20 mm in size.

The E horizon, where present, has hue of 10YP,., 7.5YK, or 5YR, value of 5 through 7 and cb_roma of 3 or 4. It is loamy sand, loamy fine sand, sandy loam, or frae sandy loam. Ironstone nodules range fi:om none to about 11 percent and are 3 to 20 mm in size.

The BA horizon, where present, has hue of 7.5YR, 5YR, or 2.5YR, value of 4 or 5 and chroma of 6 or 8. It is sandy clay loam or clay loam. Ironstone nodules range from 0 to 3 percent and are 3 to 20 mm in diameter.

The Bt horizons have hue of 5YR, 2.5YR, or 10R, value of 4 or 5 and chroma of 4 through 8. Brownish and yellowish mottles, where present, are in or below flue Bt2 horizon. Texture is sandy clay, clay loam or clay. In some pedons the Bt4 horizon is mottled in shades of red, brown and yellow. Some pedons have gray mottles below 60 inches. The clay content of the control section ranges from 36 to 55 percent with less than 30 percent silt. Plinthite ranges from 0 to 4 percent below 40 inches.

The BC horizon, where present, is below 60 inches and has the same color as the lower Bt horizons with brownish and yellowish mottles or it is mottled in shades of red, brown and yellow, In some pedons this horizon has gray mottles. It is sandy clay or sandy clay loam.

COMPETING SERIES: This includes the ESto series of the same family and the De__~, Fullerton, Henderson, Marlboro, Summerton, and Wayne-~Boro series of closely related famili~ ariwell drained. Esto soils have gray mottles in the upper Bt horizon that are inherited from the parent material. None of the series in related families recognize a kandic horizon. In addition, Dewey soils have 30 percent or more silt in the Bt horizon; Fullerton and Henderson soils have 15 to 35 percent chert fragments throughout their sola; Marlboro soils have Bt horizons of 10YR and 7.5YR hue; Stmanerton soils are mottled in shades of yellow or brown in the apper part of the Bt horizon; and Waynesboro soils are dark red.in the lower part of the Bt horizon.

GEOGRAPI-IIC SETTING: Faceville soils are on level to rolling uplands of the Coastal Plain. Dominant slopes range, from 0 to 12. percent, ~ but some, slopes.range to about. 15.percent. Elevation is 200 to 450 feet. Average annual precipitation is 45 to 50 [aches and the average annual temperature is 60 to 70 degrees F.

GEOGRAPHICALLY ASSOCIATED SOILS: In addition to the competing EsIo, Henderson and Summerton series are the Clarendon, Dothan, Grady, Greenville, Irvington, Lucy~lbis, Noboco, Norfolk., Orangeburg, Red Bay, and T~ o~~arendon, Dothan and T~"~"6'~-~~e~ 5 percent plinthite in the B horizon above 60 inches. Grady soils are poorly drained and are in shallow depressions. Greenville and Red Bay soils have dark red B horizons. Irvington and Malbis soils are moderately well drained and have more than 5 percent plinttfite in the B horizon above 60 inches. Lucy soils have a sandy surface horizon 20 to 40 inches thick. Noboco, Norfolk and Orangebu~g soils have less than 35 percent clay in the control section. ~

DRAINAGE AND PERMEABILITY: Well drained; medium nmoff; moderate permeability.

USE AND VEGETATION: Most of the acreage has been cleared and is used for growing cotton, corn, peanuts, soybeans, wheat, hay, vegetables, small grains, and tobacco. In recent years, some areas have been converted to pasture or reforested. Forests are loblolly, shonleaf, and slash pine and a me of upland oaks, hickory, and dogwood.

DISTRIBUTION AND EXTENT: Alabama, Georgia, Florida, Maryland, North Carolina, South Carolina, and Virginia. The series is extensive.

MLRA OFFICE RESPONSIBLE: Auburn, Alabama

SERIES ESTABLISHED: Decatur County, Georgia; 1933.

REMARKS: Diagnostic horizons and features recognized in this pedon are:

Ochric epipedon - the zone from the surface to approximately 5 inches (Ap horizon)

Argillic horizon - the zone bom approximately 11 to 72 inches (Btl, Bt2, Bt3, and Bt4 horizons)

Kandic horizon - the zone from approximately 11 to 72 inches with low activity clay in most of the upper 40 inches (Btl, Bt2, Bt3, and Bt4 horizons).

Revised 2/93

SIR = GA0005

MLRA = 133A

National Cooperative Soil Survey
U.S.A.

LOCATION GROSECLOSE VA+TN

Established Series
Rev. DFW-RRD
4/97

GROSECLOSE SERIES

Soils of the Groseclose series are very deep and well drained with sloWly permeable subsoils. They formed in materials weathered from limestone, shale, siltstone, and sandstone. Slopes range from 0 to 75 percent. Mean annual precipitation is about 40 inches, and mean annual temperature is about 54 degrees F.

TAxONoMIC CLASS: Clayey, mixed, mesic Typic Hapludults

TYPICAL PEDON: Groseclose loam, on a 3 percent convex west (284 degrees) facing slope in a hay field at 2,010 feet elevation. (Colors are fox moist soil)

Ap--0 to 7 inches; brown (10YR 5/3) loam; moderate frae granular structure; friable, slightly sticky, slightly plastic; common very fmc and fine roots; common fine pores; 2 percent chert gravel; moderately acid; abrupt smooth boundary. (0 to 10 inches thick)

Btl--7 to 28 inches; yellowish brown (10YR 5/6) clay; moderate 'very fine and fine subangular blocky smaeture; friable, sticky, plastic; few very fmc and frae roots; common very fine pores; few distinct dark yellowish brown clay films and few black coatings on faces ofpeds; 2 percent chert gravel; very strongly acid; clear smooth boundary.

Bt2--28 to 40 inches; mottled slrong brown (7.5YR 5/8) and yellowish red (SYR 5/g) clay; moderate medium and coarse subangular blocky structure; friable, sticky, plastic; few fine roots; common fine pores; common slickensides; many distinct clay films and few black coatings on faces of peds; 20 percent highly weathered brownish yellow and greenish gray shale and siltstone charmers that crush easily to soil material; very strongly acid; clear wavy boundary. (Combined thickness of the Bt horizon is 25 to 55 inches)

C1--40 to 51 inches; mottled strong brown (7.5YR 5/8) and yellowish red (5YR 5/8) clay; massive; friable, sticky, slightly plastic; few very frae roots; few very fmc and fine vesicular pores; common slickensides; many prominent clay flows mainly in relic rock joints; 60 percent highly weathered brownish yellow and greenish gray shale and sandstone Charmers that crush ,easily to soil materials; 1 percent chert gravel; very strongly acid; clear wavy boundary.'

C2--51 to 71 inches; mottled reddish yellow (7.5YR 6/8) and yellowish red (5YR 5/8) clay loam; massive; friable, sticky, slightly plastic; few very fmc and fine vesicular pores; common slickensides; many prominent clay flows in relic rock joints; few black coatings on rock fragments; 70 percent highly weathered greenish gray shale and siltstone charmers that crush eaSily to soil materials; very strongly acid.

TYPE LOCATION: Montgomery County, Virginia; about 1000 yards east (93 degrees) of the junction ofYA-114 and VA-663 and about 50 yards south of VA-114.

RANGE IN CHARACTERISTICS: Solum thickness ranges from 30 to 60 inches. In some pedons, variegated colors in the solum occur at depths from 20 to 40 inches below the soil surface. Depth to bedrock is more than 60 inches. Rock fragments of chert, siltstone, shale, and sandstone range from 0 to 75 percent in the A horizon and from 0 to 35 percent in the Bt and C horizon. Reaction ranges from extremely acid through strongly acid, unless limed.

The Ap horizon, where present, has hue of 7.5YR or 10YR, Value of 3 through 5, and chroma of 3 through 8. It is sandy loam, fmc sandy loam, loam, silt loam, clay loam, or silty clay loam in the fine-earth fraction.

The A horizon, where present, has hue of 7.5YR or 10YR, value of 3 or 5, and ehroma of 3 through 8. It is sandy loam, fine sandy loam, loam, silt loam, clay loam, or silty clay loam in the fine-earth fractioa.

The BA horizon, where present, has hue of 7.5YR or 10YR, value of 4 through 6, and chroma of 4 through 8. It is silt loam, loam, silty clay loam, or clay loam in the frae earth fraction.

The Bt horizon has hue of 2.5YR through 10YR, value of 4 through 6, and chroma of 4 through 8. It is clay, silty clay, silty clay loam, clay loam, or sandy clay loam in the fine-earth fraction.

The C horizon is mottled in shades of red, brown, and yellow. Texture is silty clay loam, silt loam, clay loam, clay, sandy clay loam, or sandy loam in the frae-earth fi.action.

COMPETING SERIES: These are the Agnos, Boden, Braddock, Buckhall, Buffstat, Christian, Clifton, F~airfax, Gassville, Goresville, Ilo?ell, L~e,~Monmouth, Muse, Nantahala, Pervina; (~uantaco, Sequoi~ Timberville, Trappist, Unison, Warminster, and Woolwhae series in the same~. Agno~'" Gassville, and Muse soils have a moderate shrink-swell potential. Boden soils are shallower to bedrock and contain less than 20 percent silt. Braddock soils have dominant hue of2. SYR or 10YR in the Bt horizon and a moderately permeable subsoil. Buckhall soils have rock fragments of quartz and granite. Buffstat and Littlejoe soils formed in serecite schist and other fine-grained material. Christian and Lodi soils do not have variegated colors from weathered shale and siltstone fragments at a depth of 20 to 40 inches, and in addition have moderate permeability and shrink-swell l:.otential. Clifton soils ha,~e flakes of mica throughout the solum. Fairfax, Goresville (T), and Timberville soils have lithological discontinuities in the solum. Howell and Monmouth soils have hue of 2.SY or 5Y in the lower part of the Bt horizon and in addition, Monmouth soils contain glauconite. Nantahala (T) soils are deep to paralithic contact of metasedimentary rock. Pervina soils have more than 60 inches of rainfall annually and have cool moist winters. Quantico soils have rounded quartz gravel; Sequoia and Tmppist soils are less than 40 inches to bedrock. Unison soils contain rounded or subrounded gravel or cobbles of crystalline roclcs. Warminster soils formed in Triassic red shale residuum. Woolwine soils are moderately deep to marie bedrock.

GEOGRAPItlC SETTING: Groseclose soils are on nearly level to very steep convex ridges and sideslopes in the Appalachian Valley. Slope gradients range fi.om 0 to 75 percent. These soils formed in materials weathered from interbedded limestone, shale, siltstone, and sandstone. Mean annual precipitation ranges from 36 to 44 inches and mean annual temperature ranges from 52 to 57 degrees 1~.

GEOGRAPItICALLY ASSOCIATED SOILS: These are the Poplimento, Litz, Frederick, Vertrees, Timberville, and Ernest soils. Poplimento, Berks Frederick, and Yertrees soil~'-~-~ on landscape positio=s '~imilar to those o~-'~o-roseclose series. P~ento soils have a higher base saturation. Litz soils have a cambic horizon that contains more than 35 percent rock fragments. Frederick and Vertrees soils have thicker sola. Timberville and Emest soils are along drainageways and in depressions. Timberville soils have a buffed Bt horizon; Ernest soils have a fragipan.

DRAINAGE AND PERMEABILITY: Well drained. Runoff is very slow to very rapid. Permeability is slow.

USE AND VEGETATION: Most areas are used for row crops, hay, or pasture. Corn and small grains are the principal row crops.

DISTRIBUTION AND EXTENT: Virginia, Tennessee, and Kentucky. The series is of moderate extent.

MLRA OFFICE RESPONSIBLE: Morgantown, West Virginia

SERIES ESTABLISHED: Smyth County, Virginia, 1938.

REMARKS: 1. Highly weathered shale, silts~one, and sandstone fragments that crush easily to soil materials are not considered to be rock fragments. 2. Diagnostic horizons and features recognized in this pedon are:

a. Ochric epipedon - the zone from 0 to 7 inches (Ap horizon).
b. Argilli¢ horizon - Lhe zone from 7 to 40 inches (Bt horizon).

SIR = VA0084, VA0166 (GRAVELLY)
MLRA = 125, 128
REVISED = 4/11/97 RRD

ADDITIONAL DATA: Particle size, chemical, and mineralogy data for the typical pedon (S79VA121-22-(1-6) are available from VPI&SU Soil Survey Laboratory. In addition, particle size (hydrometer), base saturation (Hath), and VPI&SU Soil Testing data are available on 32 additional pedons.

National Cooperative Soil Survey
U.S.A.

LOCATION JACKLAND VA+MD

Established Series
Rev. ACB, RRD
9/97

JACKLAND SERIES

Soils of the Jackland series axe very deep, moderately well draiaed and somewhat poorly ckained with very slow permeability. They formed in residuum that weathered from diabase and basalt of the Northern part of the Piedmont plateau. Slopes range from 0 to 15 percent. Mean annual precipitation is about 40 inches and mean annual temperature is about 55 degrees F.

TAXONOMIC CLASS: Fine, smectitic, raesic Aquic Hapludalfs

TYPICAL PEDON: Jackland silt loam on a 3 percent slope in a mixed hardwood and pine forest. (Colors are for moist soil.)

Ap--0 to 10 inches; yellowish brown (10YR 5/6) silt loam; moderate medium granular structure; friable, slightly plastic, slightly sticky; many fine, medium and coarse roots; 2 percent gravel and cobbles of diabase fragments; very strongly acid; clear smooth boundary. (2 to 12 inches thick)

BEt--10 to 15 inches; dark yellowish broom (10YR 4/4) silt loam; moderate moclium subangular blocky structure; firm, sticky, plastic; common fine and medium roots; few, fine, medium, and coarse, faint pale brown (10YR 6/3) redoximorphic depletions; many fine iron-manganese concretions; 2 percent diabase · gravel and cobble; many distinct clay films on faces ofpeds; very strongly acid; clear smooth boUndary. (0 to 10 inches thick)

Btl--15 to 30 inches; dark yellowish brown (10YR 4/4) clay; moderate coarse subangular blocky structure; very fro, very plastic, very sticky; few frae roots; common, fine and medium, distinct, gray (10YR 6/1) redoximorphic depletions; common fmc and medium iron-manganese concretions; common prominent clay films on faces ofpeds; many pressure faces and slickensides; 1 percent diabase gravel and cobbles; very strongly acid; clear smooth boundary.

Bt2--30 to 35 inches; yellowish brown (10YR 5/6) clay; moderate coarse subangular blocky structure; very firm, very plastic, very sticky; few fmc roots; common, fmc and medium iron-manganese concretions; common prominent clay fihus on faces ofpeds; many pressure faces and slickensides; 1 percent diabase gravel and cobbles; very strongly acid; dear wavy boundary. (Combined thickness of the Bt horizon ranges from 10 to 35 inches.) '

BCt--35 to 40 inches; yellowish brown (10YR 5/6) clay loam; weak medium subangular blocky structure; faxn, plastic, sticky; few fmc roots; common frae and medium iron-manganese concretions; few distinct and prominent clay films on faces ofpeds; 1 percent diabase gravel and cobbles; very strongly acid; diffuse wavy boundary. (0 to 15 inches thick)

C--40 to 65 inches; multicolored brown, yellow, green, white and black sandy loam; massive; friable, .slightly plastic, sticky; common black iron-manganese streaks; thick very plastic clay flows in crevices m the upper 15 inches; 3 percent diabase gravel and cobbles; slightly acid.

TYPE LOCATION: Prince William County, Virginia; in Conway Robinson Memorial Park, about 1.5 miles east of Gainesville, about 800 feet north of R0ute 29-211, about 300 feet west of picnic shelter.

RANGE IN CI-IARACTERISTICS: Solum thickness ranges from 30 to 48 inches. Depth to bedrock is more than 60 inches. Partially weathered diabase or basalt gravel range from to 0 to 30 percent throughout. Few boulders are in some pedons. Reaction is very strongly acid through moderately acid in

the A and upper B horizons and from very strongly acid through mildly alkaline in the lower B and C horizons.

The Ap horizon has hue of 10YR or 7.SYR, value of 4 or 5, and chroma of 3 through 6. The thin A horizon, where present, has value of 2 or 3 and chroma of 0 to 2. The Ap and A horizons are silt loam or loam in the fine-earth fraction.

The E horizon, where present, has hue of 10YR or 7.SYR, value of 4 through 6 and chroma of 3 through 6. It is silt loam in the frae-earth fraction.

The BE horizon, where present, has hue of 10YR or 7.5YR, value of 4 through 6 and chroma of 3 through 6. It is silt loam, loam, clay loam, or clay in the fine-earth fraction.

The Bt horizon has hue of 10YR or 7.5Y1L value of 4 to 6, and chroma of 3 through 6. Some pedons have hue of 2.5Y in the lower B horizon. The Bt horizon is clay in the fine-earth fraction.

The BC horizon, where present, has hue of 10YR or 7.SY1L value of 4 to 6, and chroma of 3 through 6. Some pedons have hue of 2.5Y in the lower B horizon. The BC horizon is clay loam, sandy clay loam, sandy clay, loam, silt loam, or silty clay loam in the fine-earth fraction.

The C horizon is commonly multicolored in shades of brown, yellow, white, green and black. Texture is clay loam, sandy clay loam, or sandy loam in the frae-earth fraction.

COMPETING SERIES: These are the Colp, Galland, Gorin, Keswick, and Wellex soils. All of these series are formed, in some degree, in loess cappm~d-'d3-~t have' diabase or---b-~-ic coarse fragments.

GEOGRAPHIC SETTINGS: Jaeldand soils are on the Northern part of the Piedmont Plateau uplands commonly associated with the Triassic Region. These soils are on broad convex ridges and slope gradients range from 0 to 15 percent. They have developed in residuum that,weathered from diabase, and basalt. Mean annual precipitation ranges from 36 to 44 inches and mean annual temperature ranges from 52 to 57 degrees F.

GEOGRAPHICALLY ASSOCIATED SOILS: These included the Haymarket. Legore, Montalto and Waxpool soils. The Haymarket, Legore and Montalto soils have a water table below~ches. In addition the Legore is coarser textured and the Montalto has red subsoils. The Waxpool soils have a water table above 12 inches and have an abrupt textural change.

DRAINAGE.AND PERMEABILITY: Moderately well drained and somewhat poorly drained; medium runoff; and very slow permeability in the subsoil horizon.

USE AND VEGETATION: The largest acreage is in hardwood and pine forest. Sizeable acreage is in hay and pasture and a few areas are used for corn, soybeans, small grains, and other common crops of the area. Woodland vegetation is mostly oaks, red maple, sweet gum and Virginia pine.

DISTRIBUTION AND EXTENT: Northern Virginia Maryland and Pennsylvania. The series is of moderately low extent. About 4,000 acres mapped in Prince William County, Virginia.

MIRA OFFICE RESPONSIBLE: Morgantown, West Virginia

SERIES ESTABLISHED: Prince William County, Virginia, 1985..

REMARKS: This soil has previously been mapped as Iredell series which is thermic and typic. Diagnostic horizons and features recognized in this pedon are: 1. Ochric epipedon-zone from 0 to 10 inches (Ap horizon). 2. Argillic horizon-zone from 15 to 40 inches (Bt and BCt horizons)

SIR=VA0184
MLRA=148

REVISED=9/97, RRD

National Cooperative Soil Survey
U.S.A.

LOCAT ION KELLY VA+MD

Established Series
Rev. ACB,RRD
9/97

KELLY SERIES

Soils of the Kelly series are deep and somewhat poorly drained. Permeability is slow or very slow. They formed partly in periglacially transported material and partly in residuum that weathered from gray to brown Triassic and Jurassic homfel and granulite. They area on upland flats and sideslopes in the Culpeper basin of the northern part of the Piedmont Plateau. Slopes range fi:om 0 to 7 percent. Mean annual precipitation is about 40 inches and mean annual temperature is about 54 degrees F.

TAXONOMIC CLASS: Fine, x, ermiculitic, mesic Aquic Hapludalfs

TYPICAL PEDON: Kelly silt loam - in a mixed hardwood and pine forest (Colors are for moist soil.)
0i--1 to 0 inch; partially decomposed hardwood leaves, pine needles and twigs.

A--0 to 1 inch; very dark grayish brown (10YR 3/2) silt loam; moderate fmc granular structure; -very friable; many fmc, medium and coarse roots; 2 percent angular homfel gravel; strongly acid; abrupt smooth boundary. (0 to 10 inches thick)

E--1 to 9 inches; brown (10YR 5/3) silt loam; moderate fine and medium subangular blocky stmctttre; friable; many fine and medium roots; few coarse roots; many fire and medium pores; 3 percent angular homfel and granulite gravel; strongly acid; clear smooth boundary. (0 to 10 inches thick).

Btl--9 to 19 inches; light olive brown (2.5Y 5/4) silty clay loam; moderate, fine subangular blocky structure; friable, sticky, plastic; common fmc and medium roots; common, fine and medium, distinct gray (10YR 6/1) redoximorphic depletions; few, fine and medium, distinct reddish yellow (7.SYR 6/8) soft masses of iron accumulation; many distinct clay films on faces ofpeds; 3 percent angular homfel and granulite gravels; moderately acid; gradual smooth boundaxy. (0 to 12 inches thick)

2Bt2--19 to 31 inches; very dark grayish brown (2.5Y 3/2) and dark gray (N 4/0) clay; moderate fmc and medium subangular blocky structure; firm, very plastic, very sticky; common fine and medium roots; many distinct and prominent clay films on faces ofpeds; few xedclish yellow (7.5YR 6/8) parent material streal~; 3 percent dark gray (N 4/0) to black (N 2/0) angular homfel gravel; moderately acid; clear smooth boundary. (10 to 20 inches thick)

2Bt3--31 to 38 inches; very dark gray (10YR 3/1) clay; weak medium and fine subangular blocky structure; firm, plastic, sticky; few fine roots; many distinct and prominent clay films on faces ofpeds; 14 percent angular, dark gray (10YR 4/1) homfel gravel; moderately acid; clear smooth boundary. (5 to 10 inches thick)

2BC--38 to 41 inches; mottled dark brown (10YR 3/3), dark gra3~ (10YR 4/I), black (10T-P, 2/1), and light brownish gray (10YR 6/2) gravelly silty clay; massive; friable, slightly plastic, sticky; few fmc xoots; 20 percent angular homfel gravel; moderately acid; abrupt wavy boundary (0 to 10 inches thick)

2Cr--41 to 45 inches; very dark grayish brown (10YR 3/2) partially weathered homfel.

2R--45 inches; very dark grayish brown (10YR 3/2) hard homfel.

TYPE LOCATION: Prince William County, Virginia; about 1/4 mile southeast of Gainesville, about '75 feet north of Route 674 and about 100 feet northeast of service road to Gainesville Building and

Supply.

RANGE IN CHARACTERISTICS: Solum thickness ranges from 24 to 48 inches and depth to hard bedrock is from 40 to 60 inches. Homfel and granulite gravel content range from 0 to 15 percent in the A and B horizons and from 5 to 35 percent in the BC and C horizons. Cobbles or flagstones ofhornfel or granulite make up 0 to 5 percent of the C horizon. The upper part of the solum ranges from very strongly acid through moderately acid and the lower part of the solum and C horizon are moderately acid through neutral.

The A horizon, where present, is neutral or has hue of 10YR or 2.5Y, value of 3 or 4, and chroma of 0 through 2. The A horizon is silt loam or loam in the fine-earth fraction.

The Ap horizon, where present, has hue of 10YR or 2.5Y, value of 4 or 5, chro .ma of 2 through 4. The Ap horizon is silt loam or loam in the fine-earth fraction.

The E horizon has hue of 10YR or 2.5Y, value of 4 through 6, and chroma of 2 or 3. The E horizon is silt loam or loam in the fine-earth fraction.

The Bt horizon has hue of 10YR through 5Y, value of 3 through 5, and chroma of 1 through 4. It is silt loam, loam, sandy clay loam, silty clay loam, silty clay or, clay in the fine-earth fraction.

The 2Bt horizon is neutral or has hue of 7.SYR through 2.5Y, value of 3 through 5, and chroma of 0 through 4. It is clay, . silty clay loam, or silty clay in the fine-earth fraction.

The BC horizon has hue of 10YR Or 2.5Y, value of 3 through 5, and chroma of 1 through 8. Mottles are · commonly present. The BC horizon is sandy clay loam, clay loam, silty clay loam, silty clay, or clay in the frae-earth fraction.

The C horizon, where present, is mottled or streaked withyellows and"browns.' It' is'sandy clay loam, silt loam, silty clay loam, silty clay or clay in the fine-earth fraction.

The Cr horizon is partially weathered homfel and granulite with C material in crevices.

The R horizon is hard h°mfel or granulite.

COMPETING SERIES: There are no other series in the same family.

GEOGRAPHIC SETTING: Kelly soils are on level to gemly sloping uplands of the Culpeper basin in the northern Piedmont Plateau. Slopes range from 0 to 7 percem. The soil formed partly in periglacial material and, partly in residuum weathered from gray to brown hornfel and granulite. Mean annual temperature ranges from 53 to 57 degrees F., and mean annual precipitatim~ ranges from 39 to 42 inches.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the Albano, Caflett, and Syeoline soils. Albano soils are in concave landscape positions and are poorly dr~--~-'~7. C~and Sycoline soils have less than 35 percem clay in the control sections.

DRAINAGE AND PERMEABILITY: Moderately well to somewhat poorly drained; slow to medium nmoff; slow or very slow permeability.

IJSE AND VEGETATION: Cleared areas are used for corn, wheat, pasture and hay. About 40 percent of the area is in native forest of oaks, hickory, ash, and Virginia pine.

DISTRIBUTION AND EXTENT: Culpeper basin in Virginia and MarYland, possibly the southern end of the Gett3,sburg basin of Maryland.. The series is of moderate extent.

MLRA OFFICE RESPONSIBLE: Morgantown, West Virginia

SERI-ES ESTABLISI:IED: Culpeper County, Virginia, 1943.

REMARKS: 1. Classification and type location changed to Prince William County, Virginia 1981. The original type location was inconsistent with the Kelly concept.
2. Diagnostic horizons and features recognized in this pedon are:
a. Ochric epipedon - the zone from 0 to 9 inches (A and E horizons), b. Argillic horizon - the zone from 9 to 38 inches (Bt and 2Bt horizons).

ADDITIONAL DATA: Lab date is available. Kelly soils normally have high amounts of exchangeable Mg, and Mg to Ca rations of greater than 1:1. Magnesium toxicity may be a limiting factor in use and management of these soils.

National Cooperative Soil Survey
U.S.A.

LOCATION KINSTON NC+AL FL GA MS SC TN VA
Established 'Series
WLB-RAG/Rev. JAK
07/1999

KINSTON SERIES

The Kin,qton series consists of very deep, poorly drained, moderately permeable soils that formed ia stratified loamy and sandy recent alluvium. These soils are on flood plains on the Middle Coastal Plain. Slopes range from 0 to 2 percent. Near the type location mean annual air temperature is 62 degrees F., and mean annual rainfall is 48 inches.

TAXONOMIC CLASS: Fine-loamy, siliceous, semiactive, acid, thermic Fluvaquentic Endoaquepts
TYPICAL PEDON: Kinston loam--forested. (Colors are for moist soil unless otherwise stated.)

Oe--1 to 0 inches; dark brown (7.5YR 3/2) partially decomposed temporal and discontinuous layer of hardwood leaves and grass.

A--0 to 5 inches; dark gray (10YR 4/1) loam; moderate medium granular structure; friable; many medium and coarse roots; strongly acid; clear wavy boundary. (3 to 10 inches thick)

Ago-5 to 12 inches; gray (10YR 5/1) loam; massive in place and parts to weak medium granular structure; friable; slightly sticky, slightly plastic; many medium and coarse roots; common fmc distinct brownish yellow (10YR 6/6) masses of iron accumulation; strongly acid; clear wavy boundary. (0 to 10 inches thick)

Bg--12 to 48 inches; gray (10YR 6/1) clay loam; weak medium subangular blocky structure; firm; slightly sticky, slightly plastic; few medium roots; silt coatings on walls of coarse pores; common fmc distinct strong brown and common medium distinct brownish yellow (10YR 6/6) masses of iron accumulation; strongly acid; gradual smooth boundary.

Cgl--48 to 60 inches; gray (10YR 5/1) clay loam; massive; firm; slightly sticky, slightly plastic; few silt coatings on walls of coarse pores; few fine distinct brown and common medium faint light gray (10YR 7/1) iron depletions; strongly acid; gradual smooth boundary.

Cg2--60 to 72 inches; gray (10YR 5/1) gravelly loamy sand; single grained; very friable; strongly acid.

TYPE LOCATION: Wayne County, North Carolina; 1 mile west of Goldsboro on North Carolina Highway 581,500 feet east of Little River Bridge and 100 feet north of North Carolina Highway 581.

RANGE IN CHARACTERISTICS: The loamy sediments range from 40 to 60 inches or more over gravel that is stratified with loamy and sandy material. Organic carbon content decreases irregularly to depths of 50 inches. Dark concretions are common in some pedons. The soils are strongly acid or very strongly acid except for surface layers that have been limed.

The A or Ap horizon has hue of 10YR, value of 2 through 5, and chroma of 1 to 3; or is neutral, and has value of 5. Where value is 2 or 3, the horizon is less than 6 inches th/ck. Some pedons have an Ag horizon that has hue of 10YR, value of 5 and chroma of 1; or it is neutral, and has value of 5. Texture of the A, Ap and Ag horizons is loamy sand, loam, sandy loam, fmc sandy ,loam, silt.loam.

The Bg horizon has hue of 10YR to 5Y, value of 3 to 7, and chroma of 1 to 2; hue of 5GY to 5BG, value of 6, and chroma of 1; or is neutral and has value of 4 to 6. Masses of iron accumulation of higher chroma are few to common. It fine sandy loam, sandy loam, loam, silt loam, clay loam, or sandy clay loam. The 10 to 40 inch particle-size control section contains an average of 20 to 35 percent clay, and has 15 percent or more fine sand or coarser particles. '

The Cg horizon has hue of 10YR to 5Y, value of 3 to 7, and chroma of 1 to 2; hue of 5GY to 5BG, value of 6, and chroma of 1; or is neutral and has value of 4 to 6. Masses of iron accumulation of higher chroma are few to common. The fine-earth fraction is sand, loamy sand, loamy fine sand, sandy loam, fine sandy loam, loam, sandy clay loam, or clay loam. The sandy textures in the Cg horizon are commonly below a depth of 40 inches except for thin lenses in some pedons.

Some pedons have an Ab horizon that has hue of 7.SYR to 2.5Y, value of 3, and chroma of 1 or 2. It is sandy loam, fmc sandy loam, loam, or sandy clay loam.

COMPETING SERIES: These are the Angelina and Bleakwood series in the same family and the Bibb, Chastain, Chewacla, Mantachie, Tawcaw, and Wehadkee series in other families. Angelina soils are saturated for' longer periods of time and vegetation is principally sedges, button bush, and giant sawgrass. Bleakwood soils are poorly drained, lack strata in the control section and have slightly warmer temperatures. Bibb soils contain less than 18 percent clay in the 10 to 40 inch control section. Chastain and Tawcaw soils have more than 35 percent clay in the 10 to 40 inch control section. Chewacla and Mantachie soils have colors of higher chroma just below the A1 or.Ap. Also, Chewacla soils have mixed mineralogy. Wehadkee soils have mixed mineralogy and are nonacid.

GEOGRAPItlC SETTING: Kinston soils are nearly level and are on flood plains in the Middle Coastal Plain. Slopes are less than 2 percent. The soil formed, in stratified loamy and sandy recent alluvium. Near the type location, mean annual air temperature is 62 degrees F., and the mean annual precipitation is 48 inches.

GEOGRAPI-IICALLY ASSOCIATED SOILS: In addition to the competing Bibb, Chastain, Mantachie, and Tawcaw series, is the Johnston series. Johnston soils are coarse-loamy and have an umbric epipedon.

DRAINAGE AND PERMEABILITY: Poorly drained; slow to ponded runoff; moderate permeability. Kinston soils are flooded a few to several times each year and the water table is within 10 inches of the surface during periods of high rainfall.

USE AND VEGETATION: Drained areas are used mainly for pasture, corn, soybeans, and other general farm crops. Most of this soil is in forests which consist chiefly of water-tolerant hardwoods such as sweetgum, blackgum, water oak, poplar, hickories, beech, elm, and ironwood. Loblolly pine is grown in some drained areas.

DISTRIBUTION AND EXTENT: Alabama, Arkansas, Georgia, Mississippi, North Carolina, South Carolina, Tennessee, and Virginia. The series is of large extent.

MLRA OFFICE RESPONSIBLE: Raleigh, North Carolina

SERIES ESTABLISltED: Wayne County, North Carolina; 1969.

REMARKS: Classification was changed from entisol to inceptisol (9/98) to correspond with the 8th edition of the Keys to Soil Taxonomy.

Diagnostic horiZOns and soil features recognized in this pedon are:
Ochric epipedon--the zone from the surface to a depth of 12 inches (A and Ag horizons)
Cambic horizon--the zone from 12 to 48 inches (Bg horizon)

MLRA: 133A, t53B, 153A SIR: NC0044

TABULAR SERIES DATA:

SOI-5	Soil Name	Slope	Airtemp	FrFr/Seas	Precip	Elevation
NC0044	KINSTON	'0- 2	59- 70	200-240	40- 60	50- 300

SOI-5	FloodL	FloodH	Watertable	Kind	Months	Bedrock	Eardness
NC0044	RARE	COMMON	0-1,0	APPARENT	NOV-JUN	60-60	

SOI-5	Depth	Texture	3-Inch	No-10	Clay%	-CEC-
NC0044	0-12	FSL	0- 0	98-100	5-18	3- 9
NC0044	0-12	L SIL	0- 0	'98-100	5-27	3- 11
NC0044	12-60	L CL SCL	0- 0	95-100	18-35	3- 10
NC0044	60-72	VAR	0- 0	-	-	-

SOI-5	Depth	-PH-	O.M.	Salin	Permeab	Shnk-Swll
NC0044	0-12	4.5- 6.0	2.'5.	0- 0	2.0- 6.0	LOW
NC0044	0'12	4.5- 6.0	2.-5.	0- 0	0.6- 2.0	LOW
NC0044	12-60	4.5- 5.5	0.-3.	0- 0	0.6- 2.0	LOW
NC0044	60-72					

National Cooperative Soil sUrVey
U.S.A.

LOCATION LEAKSVILLE NC+VA

Established Series
Rev. ENH:WLS:AG
02/2001

LEAKSVILLE SERIES

The Leaksville series consists of poorly drained, very slowly permeable soils that formed in residuum weathered from Triassic shale. These soils are in broad smooth concave depressions around the heads of drains and along intermittent drains. They are saturated in the winter and spring months. Water hms off the surface very slowly and ponds in the low areas. Slopes are 0 to 4 percent.

TAXONOMIC CLASS: Fine, smectitic, mesic Typic Albaqualfs

TYPICAL PEDON: Leaksville silt loam on a smooth concave 1 percent slope in pasture. (Colors are for moist soil unless otherwise stated.) .

Ap--0 to 6 inches; dark grayish brown (10YR 4/2) silt loam; weak fine granular structure; friable; many fine and medium roots; 10 percent partially weathered shale fragments up to 1 inch in size; few fmc black concretions; slightly acid; clear smooth boundary. (4 to 8 inChes thick)

Eg--6 to 9 inches; light brownish gray (2.5Y 6/2) channery silt loam; common medim distinct light yellowish brown (2.5Y 6/4) and common fine distinct yellowish brown (10YR 5/8) mottles; weak medium granular structure; friable; common fine, few medium roots; about 30 percent black (N 2/); dark grayish brown (10YR 4/2), brownish yellow (10YR 6/8), and light gray (2.5Y 7/2) partially weathered shale fragments up to 2 inches in size; few fine and medium dark concretions; medium acid; abrupt wavy boundary. (0 to 4 inches thick)

Btg--9 to 18 inches; dark grayish brown (2.5Y 5/2) clay; common fine distinct yellowish brown (10YR 5/8) and few medium faint grayish brown (2.5Y 5/2) mottles; weak prismatic structure; very firm; very sticky, very plastic; few fine and medium roots; about 10 percent dark grayish brown (2.5Y 4/2), brownish yellow (10YR 6/8) and light gray (2.5Y 7/2) partially weathered shale fragments up to 2 inches in size; few faint clay films on faces ofpeds; common sliekensides; few fine dark concretions; Slightly acid; clear wavy boundary. (4 to 20 inches thick)

CBg--18 to 24 inches; dark grayish brown (2.5Y 4/2)very channery silly clay loam; common medium distinct yellowish brown (! 0YR 5/8) and few fine faint grayish brown (2.5Y 5/2) mottles; weak medium platy structure; firm, sticky, plastic; few fine roots in cracks and in seams of shale; about 60 percem dark grayish brown (10YR 4/2), brownish yellow (10YR 6/8) and light gray (2.5Y 7/2) partially weathered shale fragments up to 3 inches in size; few thin patchy clay films on faces of plates and on f:racmre lines of shale; few dark concretions; few medium threads and bodies of light gray (2.5Y 7/2) calcium carbonate that is slightly effervescent; neutral; abrupt irregular boundary. (3 to 8 inches thick)

.Cr--24 to 30 inches; dark grayish brown (10YR 4/2) brownish yellow (10YR 6/8) and light gray (2.5Y 7/2) moderately hard shale with few bodies of dark grayish brown (2.5Y 4/2) clay in seams; massive; firm; few fine roots in cracks and seams of shale; few light gray (2.5Y 7/2) threads and bodies of calcium carbonate that is strongly effervescent; difficult to cut with a spade; neutral. (4 to 12 inches thick)

R--30 inches; hard dark colored shale..

TYPE LOCATION: Kockingham County, North Carolina..A typical pedon of Leaksville silt loam is located 1/4 mile east of Eden, 1000 feet east of State Road 1741,900 feet north of N.C. Highway 770 in pasture.

RANGE IN CHARACTERISTICS: Solum thickness ranges from 20 to 40 inches. Depth to the Cr horizon ranges from 20 to 40 inches and depth to hard bedrock l~om 24 to 60 inches. Reaction ranges from strongly acid to slightly acid in the A horizon and from moderately acid to moderately alkaline in the Btg horizon. Threads or bodies of grayish calcium carbonate range from few to common in the lower Btg, BCg, Cg, and Cr horizons in some pedons. Rock fragments of shale and quartz gravel range from 2 to 35 percent in the A horizon, from 2 to 15 percent in the Btg horizon, and from 35 to 85 percent in BCg and CBg horizons. Fragments are dominantly charmers.

The A or Ap horizon has hue of 10YR, 2.5Y, or 5Y, value of 4 to 6, and chroma of 1 to 4. Where presem, the Eg horizon has hue of 10YR, 2.5Y, or 5Y, value of 5 to 7, and chroma of 2 to 4. The A and Eg horizons are loam, silt loam, or silty 6lay loam.

The Btg horizon has hue of 10YR, 2.5Y, or 5Y, value of 4 to 6, and chroma of 1 or 2. It is mottled in shades of gray, brown, and yellow. The Btg horizon is clay, silty clay, or clay loam.

The BCg, CBg, B/C or C/B horizon, where present, has hue of 10YR to 5Y, value of 4 to 6, and chroma of 1 or 2. It is mottled in shades of gray, brown, and yellow. It is clay loam, silty clay loam, or loam in the fine earth fraction.

'The Cr horizon is dark gray and brown partially weathered shale with none to common dark grayish brown clay in fracture lines of shale.

The R horizon is hard dark colored shale.

COMPETING SERIES: These are Alnsa, Arol, Crowley, Falba, and Kemah series in the same family, and the Armenia, Iredell, Orange, Sedgefield, and White Stor-'/~ries in~d families. Alusa, Arol, Crowley, Iredell, and Whirte Store soils have clayey Btg horizons thicker than 20 inches. In addition, Iredell and White Store soilshave better'drainage: Armenia soils have.'A horizons with values' of 3 or less. Falba soils are very strongly acid to strongly acid in the Btg horizon. Kemah soils have sola more than 50 inches thick. Orange and Sedgefield soils have better drainage, and in addition, Sedgefield soils have mixed mineralogy.

GEOGRAPItlC SETTING: Leaksville soils are on broad smooth concave depressional areas in Triassic basins in the Piedmont. Slopes are mainly 0 to 2 percent but range up to 4 percent along drainageways. Mean annual precipitation is 45 inches and mean annual temperature is 60 degrees F., near the type location.

- GEOGRAPmCALLY ASSOCIATED SOILS: These are Ayersville, Pinkston, and Spray series. Ayersville and Spray soils are friable, have mixed mineralogy, and both Me on slightly higher convex knolls or ridges. Pinkston soils b_abe less than 35 percent base saturation and are on the steeper side slopes above drainageways.

DRAINAGE AND PERMEABILITY: Leaksville soils are poorly drained. Runoff and permeability are both slow. A perched water table is present at or near the surface in the late winter and spring.

USE AND VEGETATION: About one half of the acreage is used for pasture or cultivated crops. The remainder is in mixed hardwood and pine forests. Native species include southern red oak, white oak, shagbark hickory, Virginia pine, and willow oak. Understory species include winged elm, soarwood, flowering dogwood, greenbrier, eastern redbud, and huckleberry.

DISTRIBUTION AND EXTENT: The series is of small extent in a part of the Dan River Triassic Basin of North Carolina and Virginia.

MLRA OFFICE RESPONSIBLE: Raleigh, North Carolina

SERIES ESTABLISI-IED: Rockingham County, North Carolina; 1983.

REMARKS: Diagnostic features and horizons recogni?ed in this pedon are:

Ochric epipedon - the zone from the surface to a depth of 9 inches (the Ap and Eg horizons)

Abrupt textural change - the abrupt transition f~om silt loam to clay at a depth of 9 inches (the boundary between the Eg and Btg horizons)

Argillic horizon - the zone between depths of 9 and 18 inches (the Btg horizon)

Paralithic contact - the occurrence of weathered shale bedrock at a depth of 24 inches (the upper boundary of the Cr horizon)

Lithic contact - the occurrence of hard shale bedrock at a depth of 30 inches (the upper boundary of the R horizon)

SIR = NC0118

MLRA= 136

TABULAR SERIES DATA:

SOI-5'.	Soil Name	Slope	Airtemp	FrFr/Seas	Precip	Elevation
NC0118	LEAKSVILLE	0- 4	58- 62	180'-220	42- 50	350- 450

SOI-5	FloodL	FloodH	Watertable	Kind	Months	Bedrock	Hardness
NC0118	NONE		0-1.0	PERCHED	DEC-FlOR	24-60	HARD

SOI-5	Depth	Texture	3-Inch	No-10	Clay%	-CEC-
NC0118	0- 9	SILL SICL	0- 10	80- 95	10-30	5- 30
NC0118	0- 9	CN-SIL CN-L	5- 15	60- 75	10-27	5- 25
NC0118	9-18	CL C SIC	0- 10	80- 95	35-65	20- 55
NC0118	18-24	CNV-SICL CL SICL	5- 20	70- 90	10-40	5- 35
NC0118	24-30	WB				
NC0118	30-40	UWB				

SOI-5	Depth	-pH-	O.M.	Salin	Permeab	Shnk-Swll
NC0118	0- 9	5.1- 6.5	.5-2.	0- 0	0.6- 2.0	LOW
NC0118	0- 9	5.1- 6.5	.5-2.	0- 0	0.6- 2.0	LOW
NC0118	9-18	6.1- 7.8	.5-1.	0- 0	0.06- 0.2	HIGH
NC0118	18-24	6.1- 7.8	0.-.5	0- 0	0.2- 0.6	MODERATE
NC0118	24-30	-	-	~	-	
NC0118	30-40					

~ational Cooperative Soil Survey
U.S.A.

LOCATION LENOIR NC+AL MD MS NJ SC VA

Established Series
Rev. RAG:ENH
07/1999

LENOIR SERIES

The Lenoir series consists of somewhat poorly drained, slowly permeable soils thru formed on Coastal Plain uplands that formed in clayey sediments. Slopes are less than 2 percent

TAXONOMIC CLASS: Fine, mixed, semiactive, thermic Aeric Paleaquults

TYPICAL PEDON: Lenoir loam--wooded. (Colors are for moist soil unless otherwise stated.)

A--0 to 3 inches; very dark gray (10YR 3/1)loam; weak fine granular structure; very friable; many fine and medium roots; very strongly acid; clear smooth boundary. (2 to 5 inches thick)

E--3 to 8 inches; dark gray (10YR 4/1) loam; weak fine granular structure; very friable; many fine and few medium roots; many medium pores; very strongly acid; clear wavy boundary. (0 to $ inches thick)

Bt--8 to 13 inches;brownish yellow (10YR 6/6) clay loam; few medium distinct light brownish gray (10YR 6/2) and pale brown (10YR 6/3) mottles; weak medium subangular blocky structure; friable, slightly plastic, sticky; few medium roots; few medium pores; common faint clay films on faces ofpeds; very strongly acid; gradual wavy boundary. (4 to 12 inches thick)

Btgl--13 to 36 inches; gray (10YR 5/1) clay;, many medium'distinct brownish-yellow (10YR 6/8) mottles; moderate medium subangular and angular blocky structure; very fin-m, very sticky, very plastic; few fine roots; common faint clay films on faces ofpeds; few medium pores; very strongly acid; gradual wavy boundary. (6 to 25 inches thick)

Btg2--36 to 51 inches; gray (10YR 6/1) clay; few medium distinct brownish yellow (10YR 6/8) mottles; weak medium subangular and angular blocky structure; very firm, very sticky, very plastic; few fine roots, and pores; common faint clay films on faces ofpeds; very strongly acid; gradual wavy boundary. (14 to 25 inches thick)

Btg3--51 to 63 inches; gray (10YR 6/1) sandy clay; few fmc distinct brownish yellow mottles; weak medium angular blocky structure; farm, sticky, plastic; few fine roots; very strongly acid; gradual wavy boundary. (10 to 16 inches thick)

BCg--63 to 75 inches; light gray (10YR 7/1) clay; few medium lenses of sandy clay; massive; very .firm, very sticky, very plastic; very strongly acid. (7 to 25 inches thick)

TYPE LOCATION: Beaufort County, North Carolina; 11 miles east of Washington, 1/4 mile south of Five Points, 75 feet east of NC 32, across highway from Five Points Free Will Baptist Church.

RANGE IN CI-IARACTERISTICS: The clayey Btg horizon or clayey part of the BCg horizon extends to 60 to 90 inches below the surface. The soil is moderately acid to extremely acid unless limed. The A or Ap horizon has hue of 10YR or 2.5Y, or it is neutral, value of 3 to 6, and chroma of 0 to 2. The E horizon, where present, has hue of 10YR or 2.5Y, value of 4 to 8, and chroma of 1 to 4. The A, Ap, and E horizons are loam, fine sandy loam, or silt loam.

The BE or BA horizon, where present, has hue of 10YR or 2.SYR, value of 5 or 6, and chroma of 3 to 8, and has few to common mottles with chroma of 2 or less. It is loam, silt loam, fine sandy loam, silty clay loam, or clay loam.

The Bt horizon, where present, has hue of 10YR or 2.5Y, value of 5 to 7, and chroma of 3 to 8, has few to many mottles with chroma of 2 or less. In some pedons, this horizon does not have a matrix color but is mottled in shades of gray, yellow, brown, or red. The Btg horizon has hue of 10YR or 2.5Y, value of 4 to 7, and chroma of 1 or 2. Mottles in shades of yellow, brown, or red are common to many. Clay content in the upper 20 inches of the argillic horizon is 35 to 60 percent and silt content is more than 30 percent. The Bt and Btg horizons are clay, clay loam, silty clay, or silty clay loam.

The BCg horizon colors are similar to the Btg horizon. It is clay, sandy clay, Clay loam, silty clay loam, sandy clay loam, or sandy loam.

The Cg horizon, in addition to the colors of the Btg and BCg horizons, may have hue of 5Y, or it is neutral, with value of 5 to 7, and chroma of 0 to 2. It is stratified sandy, loamy, or clayey sediment.

COMPETING SERIES: (This section was not updated; 2/97) The Kinta series is the only other known series in this family. Those in closely related families are the ~,~era, Bladen, Cantey, Coxville, Craven, Dogue, Dunbar, Duplin, C~ady, Leaf, Nahunta, Pers~ff, Ro~o---b'k-'~-, S~o, Ton~ast, and · Wahee series. Kinta soils~er te~ure'~-ff-A and upper B hoFlzons with prominent re--es in the upper Bt horizon. Angie, Craven, Dogue, Duplin, and Persanti soils have audic moisture regime and lack colors with chroma of 2 or less in the upper Bt horizon. Bethera, Bladen, Cantey, Coxville, Grady, and Leaf soils have dominant chroma of 2 or less in all subh0rizons between the A and Ap horizon and 30 inches below the surface. Dunbar and Smithboro soils have kaolinitic mineralogy. Nahunta and Tomast soils have 18 to 35 percent clay in the upper 20 inches of the argillic horizon. Wahee soils have mc-~ than 10 percent weatherable minerals in the sand and silt fractions and also have than a 20 percent' decrease in clay content from the maximum within 60 inches of the surface.

GEOGRAPHIC SETTING: Lenoir soils are on nearly level interstream divides of the Coastal Plain. Slope gradients are less than 2 percent. The soil formed in stratified, clayey sediments of marine or fluvial origin. Near the type location, . the mean annual' temperature is about 63 degrees F., and the mean annual precipitation is 48 inches. Areas near the type location are not subject to flooding, but frequency for the series ranges from none to common.

GEOGRAPHICALLY ASSOCIATED SOILS: In addition to the COmpeting Bethera, Bladen, Craven, and Leaf series, these are the Bayboro, Caroline, Exum, Goldsboro, Grantham, ~urg,'~-N-~t---'~-, Norfolk, and Rains. Bayboro soils have very dark gray or black A horizons thicker than 10 inches. C~--~3'l~e soils-lh-Effmottles with chroma of 2 or less within 30 inches of the surface. Exum, Goldsboro, Grantham, Lynchburg, Nahunta, Norfolk, and Rains have 1 $ to 35 percent clay in the Bt horizon. The more poorly drained Bayboro, Bethera, Bladen, Grantham, Leaf, and Rains soils are in flats and depressions. The better drained Caroline, Craven, Exum, Goldsboro, and Norfolk soils are in slightly higher or more sloping areas. Lynchbuxg and Nahunta soils are in similar positions with Lenoir soils.

DRAINAGE AND PERMEABILITY: Somewhat poorly drained; slow runoff slow to very slow internal drainage; slow permeability.

USE AND VEGETATION: About two-thirds of the acreage is forested. Dominant trees are loblolly pine, longleafpine, sweetgum, southern red oak, water oak, white oak, red maple, blackgum, and yellow-poplar. The understory includes inkberry, sourwood, flowering dogwood, American holly, waxmyrtle, blueberry, honeysuckle, surnmersweet clethra, Carolina jessamine, poison ivy, switchcane, redbay, and greenbrier. Cleared areas are used principally for growing corn, soybeans, tobacco, cotton, small grains, peanuts, track crops, and pasture.

DISTRIBUTION AND EXTENT: Alabama, Georgia, Maryland, Mississippi, North Carolina, South Carolina, and Virginia. The series is of large extent.

MLRA OFFICE RESPONSIBLE: Raleigh, North Carolina

SERIES ESTABLISHED: Lenoir County, North Carolina; 1927.

REMARKS: Diagnostic horizons and features recognized in this pedon are:
Ochric epipedon - the zone from the surface to a depth of 8 inches.

Argllic horizon - the zone between depths of 8 to 75 inches.

Mottles and matrix colors associated with wemess begin at top of argillic horizon.
REVISED = 2/26/97, MHC

TABULAR SERIES DATA:

SOI-5	Soil Name	Slope	Airtemp	FrFr/Seas	?recip	Elevation
NC0048	LENOIR	0- 2	59- 64	185-240	40- 60	30- 170

SOI-5	FloodL	FloodH	Watertable	Kind	Months	Bedrock	Hardness
NC0048	NONE	COF~qON	1.0-2.5	APPARENT	DEC-MAY	60-60	

SOI-5	Depth	Texture	3-Inch	No-10	Clay%	-CEC-
NC0048	0- 8	L SiL VFSL	0- 0	100-100	6-20	3- 8
NC0048	0- 8	FSL	0- 0	100-100	6-20	3- 8
NC0048	8-75	C SIC CL	0- 0	100-100	35-60	7- 13

SOI-5	Depth	-pH-	O.M.	Salin	Permeab	Shnk-Swl!
NC0048	0- 8	3.5- 5.5	2.-4.	0- 0	0.6- 2.0	LOW
NC0048	0- 8	3.5- 5.5	2.-4.	0- 0	2.0-,6.0	LOW
NC0048	8-75	3.5- 5.5	0.-.5	0- 0	0.06- 0.2	MODERATE

National Cooperative Soil Survey
U.S.A.

LOCATION MUNDEN VA+NC

Established Series
Rev. DRH-JHW-DLJ
04/2000

MUNDEN SERIES

MLRA(s): 133A, 152A, 153A, 153B, 153C
MLRA Office Responsible: Raleigh, North Carolina
Depth Class: Very deep
Drainage Class: Moderately well drained
Permeability: Moderate to moderately rapid in the A and B horizon and moderately rapid in the C horizons
Surface Runoff: Slow
Parent Material: Loamy and sandy marine and flu,4al sediments
Slope: 0 to 6 percent
Mean Annual Air TemPerature (type location): 59 degrees F.
Mean Annual Precipitation (type location): 45 inches

TAXONOMIC CLASS: Coarse-loamy, mixed, semiactive, thermic Aquic Hapludults

TYPICAL pEDoN: Munden fmc sandy loam, cultivated. (Colors are for moist soil.)

Ap--0 to 8 inches; dark grayish brown (10YR 4/2) fmc sandy loam; weak fmc granular sm~eture; very friable; common fmeroots; slightly acid; abrupt smooth boundary. (5 to 10 inches thick)

Btl--8 to 15 inches; yellowish brown (10YR 5/6) sandy loam; weak medium subangular blocky structure; friable, slightly sticky, slightly plastic; few fine roots; few faint clay films on faces ofpeds; many sand grains coated and bridged with clay; strongly acid; clear smooth boundary.

Bt2--15 to 25 inches; Yellowish brown (10YR 5/6) loam; moderate medium subangular blocky structure; friable, slightly sticky, slightly plastic; few fine roots; common distinct clay films on faces of peds; many sand grains coated and bridged with clay; common medium faint light brown (7.5YR 6/4) soft masses of iron accumulation; very strongly acid; clear smooth boundary.

Bt3--25 to 32 inches; brown (10YR 5/3) and yellowish brown (10YR 5/11) sandy loam; weak medium subangular blocky structure; friable, slightly sticky, slightly plastic; few fmc roots; common fmc distinct light brownish gray (10YR 6/2) iron depletions; few faint clay films 6n faces ofpeds; many sand grains coated and bridged with clay; few small pockets of sand up to 1 1/2 inches in diameter; very strongly acid; clear smooth boundary. (Combined thickness of the Bt horizons ranges from 15 to 35 inches)

C--32 to 62 inches; yellowish brown (10YR 5/g), light brownish gray (10YR 6/2), and yellowish red (5YR 5/6) sand; single grain; loose; many stained sand grains; strongly acid.

TYPE LOCATION: City of Virginia Beach, Virginia; approximately 1.25 miles southwest of Princess Anne and 4.25 miles southeast of Stumpy Lake; 136 feet due south of North Landing Road and 100 feet southeast of small cemetery.

RANGE IN CItARACTE~STICS:
Solum Thickness: 25 to more than 50 inches
Depth to Bedrock: Greater than 60 inches
Depth to Seasonal High Water Table: 18 to 30 inches, December to April
Soil Reaction: very strongly acid to moderately acid, unless limed

Ap or A horizon:
Color--hue of 10YR or 2.5Y, value of'3 to 5, and ch~oma of 1 to 4
Texture--loamy sand, loamy fmc sand, sandy loam, fine sandy loam, or loam

E horizon (if it occurs):
Color--hue of 10YR to 5Y, value of 5 to '7, and chroma of 2 to 6
Texture--loamy sand, loamy fine sand, sandy loam, fine sandy loam, or loam

BA or BE horizon (if it occurs):
Color: hue of 10YR to 5Y, value of 5 or 6, and ckroma of 3 to 6
Texture--sandy loam, fine sandy loam, or loam

Bt horizon--the upper part of the Bt horizon has hue of 7.5YR to 2.5Y, value of 3 to 6, and ehroma of 4 to 8. The lower part of the Bt horizon has hue of 7.5YR to 2.5Y, value of 3 to 6, and chroma of 3 to 8, or it is multicolored in these and other hues without dominant matrix color
Texture--sandy loam, fmc sandy loam, or loam. Subhorizons of some pedons range to sandy clay loam
Redoximorphic features--iron masses in shades of brown, red or yellow and iron depletions in shades Of brown, olive and gray

Btg horizon (if it occurs):
Color--hue of 7.5YR to 2.5Y or is neutral, value of 3 to 6, and chroma of 0 to 2, or it is multicolored in these and other hue without dominant matrix color
Texture--sandy loam, fine sandy loam, or loam. Subhorizons of some pedons range to sandy clay loam
Redoximorphic fe~-mres--iron masses in shades of brown, red or yellow and iron depletions in shades of brown, olive and grhy

BC or CB horizon (if it occurs):
Color--hue of 7.5YR to 2.5Y, value of 3 to 6, and chroma of 3 to 8, or it is multicolored with these or other hue without dominant, matrix'color
Texture--loamy sand, sandy loam, f'me sandy loam, or loam
Redoximorphic features--iron masses in shades of brown, red or yellow and iron depletions in shades of brown, olive and gray

BCg or CBg horizon (if it occurs):
Color--hue of 7.5YR to 2.5Y, value of 3 to 6, and chroma of 0 to 2, or it is multicolored with these or other hue without dominant matrix color
Texture--loamy sand, sandy loam, fine sandy loam, or loam
Redoximorphic features--iron masses in shades of brown, red or yellow and iron depletions in shades of brown, olive and gray ~..

C horizon: ~
Color--hue of 7.5YR to 5Y, value of 5 to 7, and ehroma of 3 to 8, or it is multicolored with these or other hue without dominant matrix color
Texture--sand, fine sand, loamy sand, loamy fmc sand, sandy loam, or fine sandy loam. Some pedons have thin strata ranging from sandy clay loam to silty clay.
Redoximorphic features--iron masses in shades of brown, red or yellow and iron depletions in shades of brown, olive and gray

Cg horizon (if it occurs):
Color--has hue of 7.5YR to 5Y or is neutral, value of 5 to 7, and chroma of 0 to 2, or it is multicolored with these or other hue without dominant matrix color. Texture--sand, fine sand, loamy sand, loamy fine sand, sandy loam, or fine sandy loam. Some pedons have thin strata ranging from sandy clay loam to silty clay.
Redoximorphic features--iron masses in shades of brown, red or yellow and iron depletions in shades'of

brown, olive and gray

COMPETING SERIES: There are no other series in this family.

GEOGRAPHIC SETTING:
Landscape: Coastal Plain'
Landform: Terraces
Elevation: ~5 to 100 feet above mean sea level
Parent Material: Loamy and sandy marine and fluvial sediments
Mean Annual Air Temperature: 59 to 64 degrees
Mean Armual Precipitation: 41 to 49 inches
Frost Free Period: 190 to 240 days

GEOGRAPHICALLY ASSOCIATED SOILS:
•ansoils--somewhat poorly drained soils (seasonal high watex table 12 to 18 inches) on slightly dscapes
Bertie soils--somewhat poorly drained soils (seasonal high water table 12 to-18 inches) on slightly lower I-~-d~apes
•gj_~_ soils--well drained soils (seasonal high water table 48 to 72 inches) on similar landscapes
ragston soils--somewhat poorly drained soils (seasonal high water table 0 to 12 inches) family on slightly lower or similar landscapes
Nimmo soils--poorly drained soils (seasonal high water table 0 to 12 inches) on flats and in slight ions
Roanoke soils--poorly drained soils (seasonal high water table 0 to 12 inches) in f'me family on flats and in slight'' depressions
State soils--well drained soils (seasonal high water table 48 to 72 inches) in fine-loamy family on s-'li-~tly higher landscai~,s
Tetotum soils--moderately well drained soils (seasonal high water table 18 to 30 inches) in f'me-loamy family on similar landscapes
Tomotley soils--poorly drained soils (seasonal high water table 0 to 12 inches) in fine-loamy family on flats and in slight depressions

DRAINAGE AND PERMEABILITY:
Agricultural Drainage Class: Moderately well drained
Permeability: Moderate to moderately rapid in the A and B horizon and moderately rapid in the C horizons

USE AND VEGETATION:
Major Uses: Mostly cultivated
Dominant Vegetation: Where cultivated--eom, cotton, small grain, soybeans, and peanuts. Where woodland .... loblolly, sweetgum, red maple, yellow-poplar, white oak, southern red oak, water oak, American beech, and hickory. ,

DISTRIBUTION AND EXTENT:
Distribution: Virginia, North Carolina, and possibly Alabama, and Georgia
Extent: Moderate

MLRA OFFICE RESPONSIBLE: Raleigh, North Carolina

SERIES ESTABLISHED: City of Virginia Beach, Virginia, 1980.

REMARKS:

1. In the past Munden soils have been included with the Altavista, Bertie, Dragston, and Tetotum soils.
2. Diagnostic horizons and features recognized in this pedon are:
a. Ochric epipedon -the zone from 0 to 8 inches (Ap horizon).
b. Argillic.horizon -the zone between 8 and 32 inches (Bt horizon).
c. Aquic feature -low chroma Fe depletions in the upper 24 inches of the argillic horizon (Bt3 horizon).

SIR = VA0162

MLRA = 133A, 152A, 153A, 153B, 153C
REVISED = 2/7/96, MHC

ADDITIONAL DATA: Virginia Polytechnic Institute and State University soil survey lab data shows the typical Pedon of the Munden series to have a base saturation of 19.48 percent at a depth of 50 inches below the top of the argillic horizon. The particle-size control section has 15.6 pereem clay and 29.8 percent silt as a weighted average. ?edon sample numbers are: S74VA76-18(1-9), S76VA76-31(1-9), S77VA76-40(1-8), S77VA76-41 (1-6).

TABULAR SERIES DATA:

SOI-5	Soil Name	Slope	Airtemp	FrFr/Seas	Precip	Elevation
VA0162	MUNDEN	0-6	59-64	190-240	40-49	5-100

SOI-5	FloodL	FloodH	Watertable	Kind	Months	Bedrock
VA0162	NONE	RARE	1.5-2.5	APPARENT	DEC-APR	60-60

SOI-5	Depth	Texture	3-Inch	No-16	Clay%	-CEC-
VA0162	0-8	LS LFS	0-0	90-100	3-10	-
VA0162	0-8	SL FSL L	0-0	90-100	4-16	-
VA0162	8-32	SL L FSL	0-0	90-100-	8-18	-
VA0162	32-62	FSL LS S	0-0	90-100	2-12	-

SOI-5	Depth	-pH-	O .M.	Salin	Permeab	Shnk-Swll
VA0162	0-8	4.5-6.C	.5-1.	0-0	2.0-6.0	LOW
VA0162	0-8	4.5-6. f~	1.-2.	0-0	2.0-6.0	LOW
VA0162	8-32	4.5-6.0	.5-1.	0-0	0.6-6.0	LOW
VA0162	32-62	4.5-6.0	0.-. 5	0-0	2.0-20	LOW

National Cooperative Soil Survey
U.S.A.

LOCATION MCGARY IN+IL KY OH VA WV

Established Series
Rev. BGN-NP
10/1999

MCGARY SERIES

The McGary Series consists of very deep, somewhat poorly drained soils on lake plains, and less commonly on flood-plain steps. They formed in thin loess and the underlying calcareous, fine-textured lacustrine sediments. These soils are slowly permeable or very slowly permeable. Slopes commonly range from 0 to 2 percent, but range to 10 percent. Mean annual precipitation is about 42 inches, and mean annual temperature is about 55 degrees F.

TAXONOMIC CLASS: Fine, mixed, acti,¢e, mesic Aerie Epiaqualfs

TYPICAL PEDON: McGary silt loam on a nearly level slope in a cultivated field. (Colors are for moist soil unless otherwise stated.)

Ap--0 to 11 inches; dark grayish brown (10YR 4/2) silt loam, light gray (10YR 7/2) dry; weak coarse subangular blocky structure parting to moderate fmc and medium granular; friable; neutral; abrupt smooth boundary. (7 to 12 inches thick)

2Bt--11 to 15 inches; brown (10YR 5/3) silty clay; moderate medium subangular blocky structure; fa'm; many continuous faint grayish brown (10YR 5/2) clay films on faces of peds; common fmc distinct gray (10YR 6/1) irregularly shaped iron depletions in the matrix; moderately acid; clear smooth boundary.

2Btgl--15 to 22 inches; grayish brown (10YR 5/2) siity clay; weak tree and medium prismatic structure parting to moderate medium angular blocky; firm; many continuous distinct gray (10YR 5/1) clay films on faces of peds; common fine faint yellowish brown (10YR 5/4) irregularly shaped iron oxide masses in the matrix; few fine black (10YR 2/1) iron and manganese oxide concretions; neutral; clear smooth boundary.

2Btg2--22 to 27 inches; grayish brown (10YR 5/2) silty clay; moderate medium prismatic structure parting to moderate medium angular blocky; firm; many continuous distinct gray (10YR 5/1) day films on faces ofpeds; common'fine faint yellowish brown (10YR 5/4) iron oxide masses in the matrix; slightly effervescent in places; slightly alkaline; gradual irregular boundary.

2Btg3--27 to 42 inches; gray (10YR 5/1) silty clay; moderate medium prismatic structure parting to moderate medium angular blocky; firm; common discontinuous gray (10YR 6/1) clay films on faces of peds; common fmc distinct light yellowish brown (10YR 6/4) iron oxide masses in the matrix; few frae and medium weakly cemented calcium carbonate nodules; slightly effervescent; slightly alkaline; clear ' irregular boundary. (Combined thickness of the Bt horizons is 30 to 38 inches.)

2BCtgk--42 to 50 inches; gray (10YR 6/1) silty clay; weak coarse angular blocky structure; fa'm; few discontinuous faint gray (10YR 5/1) clay films on faces ofpeds; common fmc distinct yellowish brown (10YR 5/6) iron oxide masses in the matrix; common fmc and medium weakly cemented calcium carbonate nodules; strongly effervescent; moderately alkaline; gradual wavy boundary. (4 to 12 inches thick)

Cgk--50 to 60 inches; gray (10YR 6/1) stratified silty clay loam and silty clay; massive; firm; common fmc distinct yellowish brown (! 0YR 5/6) iron oxide masses in the matrix; common fine and meditm] weakly cemented calcium carbonate nodules; strongly effervescent; moderately alkaline.

TYPE LOCATION: Greene County, Indiana; at the north edge of Marco; 2,050 feet east and 700 feet north of the southwest comer of sec. 24, T. 6 N., R. 7 W.

RANGE IN CHARACTERISTICS: The depth to the base of the argillic horizon is 38 to 50 inches. Depth to calcium carbonates ranges from 22 to 56 inches. The particle-size control section averages 42 to 50 percent clay and 2 to 6 percent sand.

The upper part of the control section (Ap, A) has hue of 10YR, value of 4 or 5, chroma of 1 to 4. It is silt loam or silty clay loam. Reaction is moderately acid to neutral.

The second part of the control section (Bt, Btg) has hue of 10YR or 2.5Y, value of 4 to 6 and chroma of 1 to 6. Where the chroma is 3 or more, there are many coatings with chroma of 2 or less on faces of peds. It is silty clay loam or silty clay. Reaction in the upper part is very strongly acid to neutral and the lower part is neutral to slightly alkaline:

The third part of the control section (BCtgk, BC) has hue of 10YR or 2.5Y, value of 4 to 6 and chroma of 1 to 6. It is silty clay or silty clay loam, averages 40 to 50 percent clay, and 1 to 5 percent sand. Reaction is neutral to moderately alkaline.

The lower part of the control section (Ck, Cgk) has hue of 10YR or 2.5Y, value of 4 to 6 and chroma of 1 to 6. It is stratified silly clay, silty clay loam and includes thin strata of silt loam. It averages 40 to 50 percent clay, and 1 to 5 percent sand. Reaction is slightly alkaline to moderately alkaline.

COMPETING SERIES: These are the Crosby, Jeddo and Pyrmont series. Crosby and Pyrrnont soils have rock fragments in the control sectio~o so-'61~do nbt have free calcium carbonates in the control section.

GEOGRAPHIC SETTING: McGary soils are typically on flats on lake plains, and less commonly flood-plain steps. Less typically, they are on summits and shoulders of dissected lake plains. Slopes are dominantly 0 to 2 percent, but range to 10 percent. These soils formed in 6 to 20 inches of loess, and in the underlying calcareous, fmc-textured lacustrine sediments of the Wisconsin stage. Mean annual temperature ranges from 50 to 57 degrees F. and mean annual precipitation ranges from 35 to 46 inches.

GEOGRAPHICALLY ASSOCIATED SOILS: McGary soils are commonly associated with the Marldand, Montgomery, Shircliff (tentative) and ~ soils. They are also associated with the Booker and Kings soils. The well drained Marldand and mo~rately well drained Shircliff soils are on sumrmts, shou]ddr~and baekslopes of dissected lake plains. The very poorly drained Booker, Kings, Montgomery, and Zipp soils are on fiats and depressions.

DRAINAGE AND PERMEABILITY: Somewhat poorly drained. Runoff is slow, and permeability is slow or very slow. In undrained areas, depth to an intermittent perched seasonal high water table is at 0.5 to 1.5 feet in most years. On flood-plain steps, this soil is subject to frequent to rare periods of flooding.

USE AND VEGETATION: Most areas of this soil are being used to grow corn and soybeans. A few areas are used for growing wheat and hay, and a few areas are used for pasture or forest. Native vegetation is mixed hardwood forest.

DISTRIBUTION AND EXTENT: Southern Indiana, south-western and southern Ohio, northern Kentucky, south-western Illinois, Virginia and West Virginia. The series is of large extent, and is in

MLRA's 113, 114, 115, 120, 126 and 147.

MLRA OFFICE RESPONSIBLE: Indianapolis, Indiana

SERIES ESTABLISHED: Gibson County, Indiana, 1926.

REMARKS: In this update, the type location was revisited, and the typical pedon updated. A pedon from Perry County, Indiana (S91IN-123-101) shows the mineralogy to be illitic, but this series will not be assigned this mineralogy at this time. Flooded, and non-flooded drained and undrained phases are

LOCATION NASON VA

Established Series
Rev. DDR-BES
03/2000

NASON SERIES

Soils of the Nason series are deep and well drained. They are on uplands and formed in material weathered from schist and other fine grained metamorphic rocks. Slopes range from 0 to 50 percent. .- Mean annual precipitation is about 43 inches and mean annual temperature is aborn 63 degree F.

TAXONOMIC CLASS: Fine, mixed, semiactive, thermie Typic Hapludults

TYPICAL PEDON: Nason silt loam - mixed hardwood forest (Colors are for moist soil)

Oi- 1 to 0 inch, partially decomposed deciduous forest litter of leaves and twigs, and partially decomposed organic matter.

A--0 to 1 inch, very dark grayish brown (10YR 3/2) silt loam; weak fine granular structure; very friable; many fine roots; strongly acid; abrupt smooth boundary. (0 to 7 inches thick)

E-1 to 9 inches, yellowish brown (10YR 5/4) silt loam; moderate fine granular structure; friable; many fmc and medium roots; very strongly acid; clear smooth boundary. (0 to 9 inches thick)

Btl--9 to 15 inches, yellowish brown (10YR 5/8) silty clay loam; weak fine subangular blocky structure; friable, slightly plastic; slighflysticky; common mediumand large roots; few fine faint clay films on faces ofpeds; 5 percent quartz gravel; very strongly acid; clear smooth boundary.

Bt2-15 to 20 inches, strong brown (7.SYR 5/8) silty clay; moderate fine medium subangular blocky structure; friable, slightly plastic, slightly sticky; common medium roots; few fine distinct clay films on faces of peds; 5 percent quartz gravel; very strongly acid; gradual wavy boundary.

Bt3-20 to 28 inches, yellowish red (5YR 4/8) silty clay; few fine faint strong brown (7.5YR 5/6) mottles consisting of highly weathered remnants ofparem material; moderate frae and medium subangular blocky structure;' friable, slightly plastic, slightly sticky; common medium distinct clay films on faces of peds; 5 percent weathered fragments of schist; very slrongly acid; gradual wavy boundary.

Bt4-28 to 38 inches, yellowish red (5YR 4/6) charmery silty clay loam; few medium distinct strong brown (7.SYR 5/6), reddish yellow (7.5YR 6/6) and red (2.SYR 5/6) mottles consisting of highly weathered remnants of parent material; weak fmc subangular blocky structure; friable, slightly plastic, slightly sticky; few medium distinct clay films on faces of peds; 25 percent weathered fragments of . schist; very strongly acid; irregular boundary. (Combined thickness of the Bt horizon ranges from 15 to 45 inches)

C--38 to 50 inches, mottled yellowish red (5YR 4/6), red (2.5YR 5/6) and strong brown (7.SYR 5/6) ehannery silt loam saprolite; massive; firm in place; 25 percent weathered fragments of schist; very strongly acid; irregular boundary. (0 to 20 inches thick)

Ct-50 to 62 inches, weathered, partially consolidated fractured sefieite schist that can be dug with difficulty with a spade.

TYPE LOCATION: Orange County, Virginia; 2 miles north of Rhoadesville; east of Highway 621 in hardwood forest.

RANGE IN CIIARACTERISTICS: Solum thickness ranges from 25 to 50 inches. Depth to soft bedrock ranges from 40 to 60 inches. Rock fragments of quartz and schist range from 0 to 35 percent in the A, Ap, E, and Bt horizons, and 15 to 40 percent in the BC and C horizons. The solum is very strongly acid or strongly acid unless limed.

The Ap horizon, where present, has hue of 7.SYR or 10YR, value of 4 or 5, and cbroma of 2 thzough 6. It is loam, silt loam, or fmc sandy loam and eroded areas may be silty clay loam or clay loam in the fine-earth fraction.

The A horizon has hue of 7.5YR or 10YR and value of 2 through 5, and chroma of 2 through 4. Value of 2 or 3 is limited to horizons less than 6 inches thick. It is loam; silt loam, or f'me sandy loam, and eroded areas include silty clay loam in the fmc-earth fraction.

The E horizon has hue of 7.SYR or 10YR, value of 4 or 6, and chroma of 2 through 6. It is loam, silt loam or fine sandy loam in the f'me-earth fraction.

The Bt horizon has hue of 5YR to 10YR, value of 4 or 6, and chroma of 4 through 8. Mottles in shades of red, brown, or yellow may occur. Texture is silty clay, clay, silty clay loam, and clay loam in the fine-earth fraction with from 35 to 55 percent clay and more than 30 percent silt, or more than 40 percent silt plus very frae sand.

The BC horizon, where present, has hue of 2.5YR to 10YR, value of 4 or 6, and chroma of 4 through 8, and is usually mottled. The fine-earth fraction of the BC horizon is silt loam, loam, silty clay loam or clay loam.

The C horizon is multicolored in shades of brown, red, yellow, gray, or white. It is silt loam or silty clay loam saprolite in the fine-earth fraction.

The Cr horizon is weathered;· slightly fractured to-highly fractured serecite schist that can be dug with difficulty with a spade. It crushes to silt loam or silty clay loam.

· .COMPETING SERIES: These are Badin, Brockroad, Catharpin, and Tatum series in the same family. Badin soils have a depth to paralithic' c-b-fi-tact of 20 to 40 inches. Brockroad and Catharpan soils have a lithologic discontinuity within the series control section. Tatum soils have Bt horizons of 10R or 2.5YR hue.

The Alamance, Appl~g, Georgeville, Herndon, and Paeolet series are similar soils in related families. Alamance soils have fine-silty particle-size control sections. Appling and Paeolet soils have less than 30 percent silt and kaolinitic mineralogy. Georgeville and Herndon soils have kaolinitic mineralogy and do not have a Paralithic contact within 60 inches.

GEOGRAPI-IIC SETTING: Nason soils are on nearly level to very steep uplands. Slope gradients are commonly between 2 and 15 percent, but the extreme range is 0 to 50 percent. The soils formed in residuum weathered from sericite schist, phyllites, slates and other fine grained rocks. The mean annual temperature ranges from 57 to 64 degrees F., and the a'~erage annual precipitation ranges from 40 to 50 inches. Length of growing season ranges from 195 to 240 days.

GEOGRAPI-IICALLY ASSOCIATED SOILS: These are the competing Badin and Tatum soils. Also the similar Alamance, Georgeville, and Hemdon soils, and the Alamanac, Go~n, ~ ~, and~ series. Alamance and Kirksey soils have less than 35 percent clay in the Bt horizon. Goldston soils have a paralithic contact at less than 20 inches. Lignum soils have iron depletions in the upper 10 inches of the Bt horizons. Orange soils are Alfisols.

DRAINAGE AND PERME~ILITY: Well drained; medium to rapid runoff; moderate permeability.

USE AND VEGETATION: About 75 percent of the soil is in woodland of oaks, hickory, Virginia pine, and shortleaf pine. Cleared areas are used largely for growing corn, small grain, mixed hay, and

DISTRIBUTION AND EXTENT: Mainly in the northern part of the thermic Piedmom Plateau in Virginia. The series is of small extem.

MLRA OFFICE RESPONSIBLE: Raleigh, North Carolina

SERIES ESTABLISHED: Orange County, Virginia, 1927.

REMARKS: Diagnostic horizons and features recognized in this pedon are:

Ochric epipedon - the zone from 0 to 9 inches (A and E horizons)

Argillic horizon - the zone from 9 to 28 inches (Bt horizons)

paralithic contact at 50 inches.
SIR = VA0012, VA0144 (GRAVELLY)

MLRA = 136

REVISED = 7/5/93, MHC

ADDITIONAL DATA:

SOI-5 Soil Name Slope Airtemp FxFr/Seas Preeip Elevation
VA0012 NASON 0- 50 57- 64 195-240 40- 50 250- 900
VA0144 NASON 0- 45 57- 64 195-240 40- 50 250- 900

SOI-5 FloodL FloodH Watertable Kind Months Bedrock Hardness
VA0012 NONE 6.0-6.0 - 40-60 SOFT
VA0144 NONE 6.0-6.0 - 40-60 SOFT

SOI-5 Depth Texture 3-Inch No-10 Clay% -CEC-
VA0012 0- 9 L SIL 0- 5 75-100 10-27 -
VA0012 0- 9 VFSL FSL 0- 5 65-100 5-20 -
VA0012 0- 9 SICL CL 0- 5 75-100 27-40 -
VA0012 9-38 SICL SIC C 0- 5 75-100 35-50 -
VA0012 38-50 CN-SIL SILL 0- 5 45- 75 10-25 -
VA0012 50-60 WB ....
VA0144 0- 9 GR-L GR-SIL GR-FSL 0- 10 55- 75 6-12 -
VA0144 0- 9 GR-SICL 0- 10 55- 75 28-35 -
VA0144 9-38 SICL SIC C 0- 5 75-100 28-53 -
VA0144 38-50 CN-SIL SIL SICL 0- 5 50- 75 10-35 -
VA0144 50-60 WB ....

SOI-5 Depth -pH- O.M. Salin Permeab Shnk-Swll
VA0012 0- 9 4.5- 6.5 1.-3.0-0 0.6- 2.0 LOW
VA0012 0- 9 4.5- 6.5 1.-3.0- 0 0.6- 2.0 LOW
VA0012 0- 9 4.5- 6.5 1.-3.0- 0 0.6- 2.0 LOW

VA0012 9-38 4.5- 5.5 0.-.5 0- 0 0.6- 2.0 MODERATE
VA0012 38-50 4.5- 5.5 0.-.5.0- 0 0.6- 2.0 LOW
VA0012 50-60 - - - 0.00-0.06
VA0144 0- 9 4.5- 6.5 2.-5.0- 0 0.6- 2.0 LOW
VA0144 0- 9 4.5- 6.5 2.-5.0- 0 0.6- 2.0 LOW
VA0144 9-38 4.5- 5.5 0.-.5 0- 0 0.6- 2.0 MODERATE
VA0144 38-50 4.5- 5.5 0.-.5 0- 0 0.6- 2.0 LOW

VA0144 50-60 - - - 0.00-0.06

National Cooperative Soil Survey
U.S.A.

LOCATION NIMMO VA+NC

Established Series
Rev. DRH-JHW-MHC
06/2000

NIMMO SERIES

MLRA(s): 133A, 153A, 153B
MLRA Office Responsible: Raleigh, North Carolina
Depth Class: Very deep
Drainage Class: Poorly drained
Permeability: Moderate in the A and B horizons and moderately rapid to rapid in the C horizons
Surface Runoff'. Slow
Parent Material: Loamy and sandy marine and fluvial sediments
Slope: 0 to 2 percent
Mean Annual Air Temperature (type location): 59 degrees F.
Mean Annual Precipitation (type location): 44 inches

TAXoNoMIC CLASS: Coarse-loamy, mixed, semiactive, therrnic Typic Endoaquults

TYPICAL PEDON: Nimmo loam -in a cultivated field. (Col-. :.~ are for moist soil.)

Ap--0 to 7 inches; dark gray (10YR 4/1) loam; weak fine granular structure; friable, nonsticky, slightly plastic; many fine roots; common clean sand grains; strongly acid; abrupt smooth boundary. (0 to 12 inches thick)

Btgl--7 to 14 inches; light gray (10YR 6/1) fmc sandy loam; weak fine subangular blocky structure; friable; slightly sticky, slightly plastic; many fine and few medium and coarse roots; common medium prominent yellowish brown (10YR 5/6) iron masses; many sand grains coated and bridged with clay; strongly acid; clear smooth boundary.

Btg2--14 to 25 inches; gray (10YR 5/1) loam; moderate medium subangular blocky structure; friable, slightly sticky, slightly plastic; common fine medium and coarse roots; many medium prominent yellowish brown (10YR 5/6) iron masses; many sand grains coated and bridged with clay; few faint clay films on faces ofpeds; very strongly acid; clear smooth boundary.

Btg3--25 to 33 inches; gray (10YR 5/1) fmc sandy loam; weak fine subangular blocky structure; friable; slightly sticky, slightly plastic; 6ommon frae and medium roots; many medium prominent yellowish brown (10YR 5/6) iron masses; many sand grains coated and bridged with clay; few faint clay films on faces ofpeds; very strongly acid; clear smooth boundary. (combined thickness of Btg horizon is 15 to 40 inches thick)

2Cg--33 to 60 inches; light gray (10YR 7/1) fine sand; single grain; loose; common very frae black mineral grains; few medium yellowish brown (10YR 5/4) sand grains; few coarse sand grains; strongly acid.

TYPE LOCATION: City of Virginia Beach, Virginia; 4.5 miles south of Ptmgo; approximately .85 miles southeast of the junction of Vaughan Road and Princess Anne Road, and .8 miles northeast of the junction of Mill Landing Road and Princess Anne Road.

RANGE IN CHARACTERISTICS:
Solum Thickness: 25 to 45 inches
Depth to Bedrock: Greater than 60 inches

Depth to Seasonal High Water Table: 0 to 12 inches, December to April

Soil R~action: Extremely acid through strongly acid throughout the soil, unless limed

A or Ap horizon
Color--hue of 10YR to 5Y or is neutral, value of 2 to 5, and cb_roma of 1 or 2. Where value is 2 or 3, the horizon is less than 6 inches thick.
TEXTURE--loamy sand, loamy fmc sand, sandy loam, fmc sandy loam, or loam

E horizon (if it occurs):
Color--hue of 10YR to 5Y or is neutral, value of 4 to 7, and chroma of 1 or 2
Texture--loamy sand, loamy fine sand, sandy loam, fine sandy loam, or loam ' '

BE horizon (if it occurs)
Color--hue of 10YR to 5Y or is neutral, value of 4 to 7, and chroma of 1 or 2
Texture--loamy sand, loamy fmc sand, sandy loam, fmc sandy loam, or loam

Btg horizon:
Color--hue of 10YR to 5Y or is neutral, value of 4 to 7, and chroma of 0 to 2, but dominantly 1
Texatre--loam, fine sandy loam or sandy loam. Some pedons have thin layers of silt loam or sandy clay loam.
Redoximorphic features--iron masses in shades of brown, red or yellow and iron depletions in shades of brown, olive and gray

2C or C horizon (if it occurs):
Color--hue of 7.5YR to 5Y, value of 3 to 8, and chroma of 3 to 8
Texture--coarse sand, sand, loamy sand, loamy frae sand, or fmc sand in the fmc earth fraction. Strata or layers of freer texture are in some pedons.

2Cg or Cg horizon
Color--hue of 7.5YR to 2.5Y or is neutral, value of 3 to 8, and cb_roma of 0 to 2
Texture--coarse sand, sand, loamy sand, loamy frae sand, or fine sand in the fmc-earth fraction. Strata of freer-texture are in some pedons
Redoximorphic features (if they occur)--iron masses in shades of brown, red or yellow and iron depletions in shades of brown, olive and gray

COMPETING SERIES: There are no other known series in the same family

GEOGRAPHIC SETTING:
Landscape: Coastal Plain
Landform: Marine Terrace
Elevation: 5 to 150 feet above mean sea level (elevation at the type location is about 6 feet)
Parent Material: Loamy and sandy sediments
Mean Annual Air Temperature: 57 to 65 degrees
Mean Annual Precipitation: 35 to 45 inches
Frost Free Period: 175 to 210 days

GEOGRAPHICALLY ASSOCIATED SOILS:
Acredale soils--poorly drained soils (seasonal high water table 0 to 12 inches) in fmc-silty family on similar landscapes
_~ soils--well drained soils (seasonal high water table 48 to 72 inches) on higher landscapes
ragston soils--somewhat poorly drained soils (seasonal high water table 12 to 30 inches) on higher landscapes
Munden soils--moderately well drained soils (seasonal high water table 18 to 30 inches) on higher landscapes

Po~smouth soils--very poorly drained soils (seasonal high water table 0 to i2 inches) in fine-loamy family on similar landscapes
Roanoke soils--poorly drained soils (seasonal high water table 0 to 12 inches) in fmc family on similar landscapes

State soils--well drained soils (seasonal high water table 48 to 72 inches) in fine loamy family on higher ~capes
Tetotum soils--moderately well drained soils (seasonal high water table 18 to 30 inches) in fine-loamy family on higher landscapes
Tomotle. . y sOils--poorly drained soils (seasonal high Water table 0 to 12 inches) in f'me-loamy family on snmlar landscapes '

DRAINAGE A/ND PERMEABILITY:
AgricultUral Drainage Class: Poorly drained
Permeability: Moderate in the A and B horizons and moderately raPid to rapid in the C horizons
Runoff.' Slow

USE AND VEGETATION:
Major Uses: Mostly cultivated
Dominant Vegetation: Where cultivated--corn, soybeans, small grain, truck crops, and pasture. Where wooded--loblolly pine, Willow oak, yellow poplar, red maple, water tupelo, sweetgum, blackgurn, and water oak. Understory plants include inkberry, large gallberry, southern bayberry,

DISTRIBUTION AND EXTENT~
Distribution: Lower Coastal Plain of Virginia, North Carolina, Maryland and possibly Alabama
Extent: Moderate

MLRA OFFICE RESPONSIBLE: Raleigh; North Carolina

SERIES ESTABLISHED: City of Virginia Beach, Virginia, 1980.
REMARKS: Diagnostic horizons and features recognized in this pedon are:
a. Ochric epipedon -the zone from the surface-to a depth of 7 inches (Ap horizon).
b. Argillic horizon -the zone from 7 to 33 inches (Btg horizon).

SIR=VA0161

MLRA=133A, 153A, 153B

ADDITIONAL DATA:

REVISED=9/6/95,MHC

TABULAR sERIEs DATA:

SOI-5	Soil Name	Slope	Airtemp	FrFr/Seas	Precip	Elevation
VA016t	NIMMO	0-2	57-65	175-210	35-45	5-150

SOI-5	FloodL	FloodH	Watertable	Kind	Months	Bedrock
VA0161	NONE		0-1.0	APPARENT	DEC-APR	60-60

SOI-5	Depth	Texture	3-Inch	No-10	Clay%	-CEC-
VA0161	0-7	L FSL SL	0-0	95-100	4-14	
VA0161	0-7	LS LFS	0-0	95-100	3-10	
VA0161	7-33	L FSL SL	0-0	95-100	8-18	
VA0161	33-60	LS FS S	0-0	70-100	1-8	

SOI-5	Depth	-pH-	O.M.	Salinity	Permeability	Shrink-Swell
VA0161	0-7	3.6-5.5	1.-3.	0-0	2.0-6.0	LOW
VA0161	0-7	3.6-5.5	1.-2.	0-0	2.0-6.0	LOW
VA0161	7-33	3.6-5.5	0.-. 5	0-0	0.6-2.0	LOW
VA0161	33-60	3.6-5.5	0. -. 5	0-0	2.0-20	LOW

National Cooperative Soil Survey
U.S.A.

LOCATION PENN PA+MD NJ VA

Established Series
Rev. GDM-EAW
06/2001

PENN SERIES

The Penn series'consists of moderately deep, well drained soils formed in materials weathered from noncalcareous reddish shale, siltstone, and fmc-grained sandstone normally of Triassic age. Slopes range from 0 to 60 percent. Permeability is moderate or moderately rapid. Mean annual precipitation is 43 inches. Mean annual temperature is 55 degrees F.

TAXONOMIC CLASS: Fine-loamy, mixed,' superactive, mesic Ultic Hapludalfs

TYPICAL PEDON: Penn silt loam - cropland. (Colors are for moist soil unless otherwise noted.)

Ap--0 to 8 inches; dark reddish brown (2.5YR 3/4) silt loam; weak frae and medium granular structure; friable, nov_sticky, slightly plastic; many roots; many pores; 10 percent shale and siltstone fragments; slightly acid; clear wavy boundary. (6 to 12 inches thick)

Btl--8 to ! ! inches; reddish brown (2.5YR 4/4) charmery silt loam; weak fine and y. ~ediutn'subangular blocky structure; friable, slightly sticky, slightly plastic; common roots; many pores; common faint clay films on faces ofpeds; 15 percent shale and siltstone fragments; slightly acid; gradflal wavy boundary. (2 to 6 inches thick)

Bt2--11 to 17 inches; reddish brown (2.5YR 4/4) channery silt loam; moderate f'me and medium. · subangular blocky structure; friable, slightly sticky, slightly plastic; few roots; many faint clay films on faces ofpeds; 25 percent shale and siltstone fragments; moderately acid; clear wavy boundary. (4 to 14 inches thick)

Bt3--17 to 21 inches; weak red (10YR 4/4) charmery silt loam; weak medium subangular blocky structure; finn, slightly sticky, slightly plastic; few faint clay films on faces ofpeds; common black coatings on rock fragments; 40 percent shale and siltstone fragments; moderately acid; clear wavy boundary. (0 to 9 inches thick)

C--21 to 34 inches; weak red (10R 4/4) channery silt loam; weak medium subangular blocky structure; . firm, slightly sticky, slightly plastic; few faint clay films on faces ofpeds; common black coatings on ' rock fragments; 40 percent shale and siltstone fragments; strongly acid. (0 to 14 inches thick)

Cr--34 inches; dusky red (1 OR 3/3) soft ,fractured, shale and siltstone bedrock.

TYPE LOCATION: Montgomery County, Pennsylvania; Perkiomen Township, 1 mile N of Trappe, 4000 feet N intersection of U.S. Route 422 and Church road, 200 feet E of Church road in field.

RANGE IN CI-IARACTERISTICS: Solum thickness ranges from 17 to 34 inches. Depth to bedrock ranges from 20 to 40 inches. Rock fragment content, by volume, ranges from 2 to 30 percent in the A horizon, from 5 to 50 percent in individual horizons of the B, and from 30 to 90 percent in the C horizon, the control section a-qerage is less than 35 percent. The soil, where unlimed, ranges from extremely through strongly acid in the upper part of the solum, is strongly acid or moderately acid in the lower part of the solum, and ranges from strongly acid through slightly acid in the C horizon.

The Ap horizon has hue of 7.SYR through 1 OR, value of 3 or 4, and cb_roma of 2 through 4. Texture is silt loam or loam in the fine-earth fraction.

The B horizon has hue of 10R thxough 5YR, value of 3 through 6, and chroma of 2 through 6. Texture is silt loam, loam or silty clay loam in the fine-earth fraction.

The C horizon has hue of 1 OR through 5YR, value of 3 or 4, and chroma of 2 through 4. Texture is sik loam, loam; or sandy loam in the fine earth-fraction.

COMPETING SERIES: The Athol, Bolton, Bookwood, Brecknock, Caribel(T), Carpenter, Cateache, C.ulleoka, Door, Dormont, D~D~s, Frondoff, Crrayford, Greencreek, ~, Lamotte, '
Legore, Loudonville, Manassas, Mechanicsburg, Morrison, Myersville, Neshaminy, O~tlands, Panorama, Ryder, Spriggs, Sudley, Washington, Weeclmark, Westmoreland, Wheeli/ig, and"'. ~" ' Williamsburg series are in the same family. All of th6se soils except Cateache; CUlleoka,~ Fr°ndorf, Loudonville, Oatlands, Ryder and Spriggs are more than 40 inches l~om the soil surface to bedrock. Cateache soils have less than 15 percent fine and coarser sand. Culleoka, Frondorf, Loudonville, and Ryder soils have hue of 7.SYR or yellower in the B horizon. Oatlands soils contain rock fragments of triassic sandstone and conglomerate. Spriggs soils have rock fragments of gneiss and schist.

GEOGRAPItlC SETTING: Penn soils are on nearly, level to steep moderately dissected uplands. Slopes range from 0 to 60 percent. They formed in materials weathered from noncalcareous reddish shale, siltstone, and fine-grained sandstone, normally of Triassic age. The climate is humid temperature. Mean annual precipitation ranges from 38 to 48 inches, mean annual air temperature ranges from 50 to 59 degrees F, and the frost free season ranges from 170 to 200 days.

GEOGRAPI-IICALLY ASSOCIATED SOILS: These are the Abbottstown, Athol, Bucks., Croton, Klinesville, Lewisberry, Readington, and Reaville soils. The Abbottstown, Croton, an~["[eadington soils have fragipans. Athol and Lewisberry soils are more than 40 inches to bedrock. Klinesville soils have bedrock within 20 inches. Reaville soils have mottles in the top 10 inches of the agrillic horizon.

DRAINAGE AND pERMEABILITY: Well drained; nmoffis medium to very rapid and permeability is moderate or moderately rapid,

USE AND VEGETATION: About 75 percent cleared and largely used for rotation cropland. Woodlands are mixed hardwoods dominated by oaks.

DISTRIBUTION AND EXTENT: Southeastern Pennsylvania, New Jersey, Maryland and Virginia. The series is of large extent.

MLRA OFFICE RESPONSIBLE: Morgantown, West Virginia

SERIES ESTABLISHED: Lebanon County, Pennsylvania,. 1901.

REMARKS: Diagnostic horizons and features recognized in this pedon are:

1. Ochric epipedon - the zone from the surface of the soil to a depth of 8 inches (Ap horizon).

2. Argillic horizon - the zone from 8 to 21 inches (Bt horizon).

ADDITIONAL DATA: Laboratory data are available on two pedons sampled in Montgomery County, Pennsylvania and one pedon sampled in York County, Pennsylvania.

National Cooperative Soil Survey
U.S.A.

LOCATION SPOTSYLVANIA VA

Established Series
Rev. JHE, NAM
07/1999

SPOTSYLVANIA SERIES

Soils of the Spotsylvania series are deep and well drained with moderate permeability. They formed in medium and fine textured Coastal Plain sediments and residuum from granite, gneiss or schist. They are on uplands arid slopes range from 0 to 25 percent. Mean annual precipitation is about 107 em and mean annual air temperature is above 15 degrees C.

TAXONOMIC CLASS: Fine, kaolinitic, theme Typic Hapludults

TYPICAL PEDON: Spotsylvania fmc sandy loam on a convex slope of 4 percent under mixed pine and hardwood forest.

01--3 to 0 inch; partially decomposed, pine needles, oak leaves and twigs.

Al--0 to 5 cm; very dark grayish brown (10YR3/2) fmc sandy loam; weak frae granular structure; very friable; many ,fine and medium roots; 2 percent rounded quartz pebbles; very strongly acid; clear smooth boundary. (0 to 8 cm thick)

A2--5 to 25 em; light yellowish brown (10YR6/4) fmc sandy loam; moderate fine granular structure; very friable; many fine and medium roots; 2 percent rounded quartz pebbles; very strongly acid; clear smooth boundary. (0 to 30 em thick)

Blt--30 to 48 em; yellowish brown (10YR5/6) clay loam; weak fmc subangular blocky structure; friable; slightly sticky, slightly plastic; many fmc and medium roots; few thin clay films on faces of peds; 2 percent rounded quartz pebbles; very strongly acid; clear smooth boundary. (0 to 25 cm thick)

B21t--48 to 79 em; strong brown (7.5YR5/6) clay; common medium and coarse faint yellowish red (5YR5/6) and brownish yellow (10YR6/8) mottles; moderate frae subangular blocky structure; firm; common fine and medium roots; continuous thin clay films on faces peds; 2 percent rounded quartz pebbles; stone line 5 em thick at the lower boundary with 15 percent rounded and subrounded quartz pebbles up to 5 em in diameter; very strongly acid; abrupt smooth boundary. (10 to 60 cm thick)

IIB22t--79 to 104 cra; yell6wish red (5YR5/6) clay; common medium and fine faint yellowish brown (10YRS/6) mottles; moderate fine subangular blocky structure; tin,a, slightly sticky, plastic; continuous thin clay films on faces ofpeds; 2 percent angular quartz pebbles; few fmc flakes of mica; very strongly acid; clear smooth boundary, (13 to 50 cm thick)

llB3t--104 to 137 em; yellowish red (5YR5/6) clay; common medium and coarse faint yellowish brown (10YR5/6) and few medium and coarse prominent white (10YR8/1) mottles; fn-m; slightly sticky, slightly plastic; common medium clay films; commOn fmc flakes of mica; 2 percent weathered feldspar fragments; 2 percent angular quartz pebbles; very strongly acid; gradual smooth boundary. (0 to 36 cm thick)

IIC-- 137 to 188 cm; multicolored red (2.5 YRS/8), strong brown (7.5YR5/6), white (10YRS/1) and brownish yellow (10YR6/8) sandy clay loam; weathered granite gneiss; massive; friable; few medium and thick clay flows into upper part; common fmc flakes of mica; 10 percent weathered feldspar fragments; 2 percent angular quartz pebbles; very strongly acid; gradual smooth boundary.

TYPE LOCATON: SpotsYlvania county, virginia; 5 km south southeast of Spotsylvania. About 2.4

km north of State Route 606 and about 1.6 km east of Snell on the east side of private drive 60 meters east of State Route 722.

RANGE IN CHARACTERISTICS: Solum thickness ranges from 100 to more than 150 cm. Depth to the lithologic discontinuity ranges from 50 to 100 cm. Depth to hard bedrock is more than 180 cm. Reaction is strongly or very strongly acid unless limed. The upper material contains up to 15 percent of rounded and sub- rounded quartz pebbles and the II material conmln.q up to 15 percent of angular feldspar fragments and some pedons contain a few angular quartz fragments. Stone lines commonly are present at the contact between the B2 and IIB2 horizons.

A1 horizons have hue of 10YR or 2.5Y, value of 3 through 5 and chroma of 2 through 4. A2 horizons have hue of;10YR or 2.5 Y, value of 5 or 6, and cb_roma of 3 through 8. Ap horizons, when present, have hue of 10YR or 2.5Y, value of 4 through 6, and eh_roma of 3 or 4. Textures of A horizons are fine sandy loam, sandy loam or loam.

B1 and B2 horizons have hue of 7.5YR, 10YR, or 2.5Y, value of 5 or 6, and chroma, of 4 through 8. Textures of the B 1 horizons are clay loam, loam, or sandy clay loam and the B2 horizons are clay loam or clay. IIB horizons have hue of 5YR, 715YR or 20YR, value of 4 or 5, and chroma of 6 or 8 and commonly contain high chroma mottles. Textures of the liB horizons are clay loam or clay. Flakes of mica are few many in the lib horizons.

C horizons are multicolored and commonly are in shades of red, brown, yellow, and white. They are' very strongly weathered gneiss, schist, and granite that easily crash to sandy clay lorn, loam, or sandy loam textures.

COMPETING SERIES: These are the Appling, Argaon, Cecil, Chestatee, Oeorgeville, Hemdon, •a ' "'Madison' Mayodan, Nankin, Pacolet, and Wedowee series in the same family. Ali of these soils lithologic discontinuity. The Christian, C~peper, and Lodi series are in closely related families. All ofthese.lack.a.lithologic, discontinui~. In addition,~the.~ian, Culpeper, andLodi soils aremesic

GEOGRAPItlC SETTING: The Spotsylvania soils are on nearly level to moderately steep uplands. Slopes are dominantly 2 to 7 percent but range from 0 to 25 percent. The upper solum formed in loamy or clayey sediments often of Coastal Plain origin, and the lower solum formed in material that weathered from granite, gneiss, and schist. The climate is humid with mean annual precipitation of about 107 em and a mean annual temperature above 15 degrees C.

GEOGRAPI-IICALLY ASSOCIATED SOILS: These are the Appling, Cecil, Faceville., Fluvanna, gnd Louisburg soils. All of these soils lack lithologic discontinuity.

DRAINAGE AND PERMEABILITY: Well drained; medium runoff; moderate permeability.

USE AND VEGETATION: Spotsylvania soils are used for growing corn, small grains, hay and pasture. Wooded areas are mixed species of oak, hickory, pine and poplar.

DISTRIBUTION AND EXTENT: Virginia, and possibly North Carolina and South Carolina. The series is of moderate extent.

MI,RA OFFICE RESPONSIBLE: Raleigh, North Carolina

SERIES ESTABLISI-IED: Chesterfield County, Virginia, 1974.

REMARKS: These soils were formerly mapped in the Chesterfield series which was made inactive.
TABULAR SERIES DATA

SOI-5 Soil Name Slope Airtemp FrFr/Seas Precip Elevation
VA0080 SPOTSYLVAN 0- 25 59- 64 185-220 35- 45 250- 800

SOI-5 FloodL FloodH Watertable Kind Months Bedrock Hardness
VA0080 NONE 6.0-6.0 - 60-60

SOI-5 Depth Texture 3-Inch No-10 Clay% -CEC-
VA00$0 0-10 FSL SL L 0- 0 80- 95 5-27 -
VA0080 10-19 CL SCL L 0- 5 75- 95 20-40 -
VA0080 19-54 C CL 0- 5 75- 95 35-55 -
VA0080 54-74 SCL L SL 0- 5 70- 95 10-35 -

SOI-5 Depth -pH- O.M. Salin Permeab Shnk-Swll
VA0080 0-10 4.5- 6.0.5-2.0- 0 0.6- 6.0 LOW
VA0080 10-19 4.5- 5.5 0.-.5 0- 0 0.6- 2.0 LOW
VA0080 19-54 4.5- 5.5 0.-.5 0- 0 0.6- 2.0 MODERATE
VA0080 54-74 4.5- 5.5 0.-.5 0- 0 0.6- 2.0 LOW

National Cooperative Soil Survey
U.S.A.

LOCATION YEMASSEE SC+AL FL VA

Established Series
Rev. DJD
07/1999

YEMASSEE SERIES

The Yemassee series consists of very deep, somewhat poorly drained, moderately permeable, loamy soils that formed in marine sediments. These soils are on terraces and broad flats of the lower Coastal Plain. Slopes range from 0 to 2 percent.

TAXONOMIC CLASS: Fine-loamy, siliceous, semiactive, thermic Aeric Endoaquults

TYPICAL PEDON: Yemassee loamy frae sand--foreSted. (Colors are for moist soil.)

A--0 to 7 inches; black (10YR 2/1) loamy fme sand; weak frae subangular blocky structure; very friable; many medium roots; many medium holes; few uncoated sand grains; very strongly acid; abrupt smooth boundary. (4 to 10 inches thick)

E--7 to 12 inches; pale brown (10YR 5/3) loamy' fine sand; weak fine granular structure; friable; many fine and medium roots; few fmc holes; some A material moved down into root channels; common medium faint light brownish gray (10YR 6/2) iron depletions; very strongly acid; clear smooth boundary. (0 to 11 inches thick)

Bt--12 to 20 inches; pale brown (2.5Y 6/3) sandy clay loam; moderate medium subangular blocky structure; friable; common-fine roots;, few f'me holes; thin patchy-faint clay films in old. root' charmels: and on faces of some peds; many medium distinct light brownish gray (10YR 6/2) iron depletions, and many medium prominent yellowish brown (10YR 5/6) masses of iron accumulation; very strongly acid; clear smooth boundary.

Btgl--20 to 34 inches; gray (10YR 6/1) sandy clay loam; moderate medium subangular blocky structure; friable; few fmc roots; thin patchy faint clay films on faces of some peds; common medium faint grayish brown (10YR 5/2) iron depletions, and common prominent strong brown (7.5YR 5/8) masses of iron accumulation; very strongly acid; clear smooth boundary.

Btg2--34 to 50 inches; gray (10YR 6/1) sandy clay loam; moderate medium subangular blocky structure; friable; few fmc roots; thin patchy clay films on faces of some peds; few uncoated sand grains; many coarse prominent yellowish brown (10YR 5/8) masses of iron accumalation; very strongly acid; gradual smooth boundary. (Combined thickness of the Bt horizon is 15 to more than 40 inches.)

BCg--50 to 75 inches; light gray (10YR 7/2) sandy loam; weak fine granular structure; very friable; common medium prominent yellowish red (5YR 5/8) masses of iron accumulation; strongly acid; gradual smooth boundary. (0 to 30 inches thick)

Cg--75 to 90 inches; gray (10YR 6/1) sand; single grained; loose; strongly acid.

TYPE LOCATION: Georgetown County, South Carolina; south On U.S. Highway 17 to Penny Royal Road (State Highway 42); west for 3.3 miles to Mouresina Road; north 1.0 mile to unmarked road; west for 0.4 mile. Site is 150 feet south of the centerline of the road.

RANGE IN CI-IARACTE~STICS: Solum thickness is 40 to more ~ 70 inches. The soil is extremely acid to slightly acid in the A horizon and extremely acid to strongly acid in the B and C horizons. Few to common frae flakes of mica and fmc black minerals are in the lower part of the B and C horizons of many pedons. Some pedons have few to common concretions.

The A or Ap horizon has hue of 10YR to 5Y, or it is neutral, value of 2 to 5, and chroma of 0 to 2. Where the value is less than 3.5, the A or.Ap horizon is less than 10 inches thick. The E horizon, where present, has hue of 10YR or 2.5Y, value of 5 to 7, and cb_roma of 2 to 4. Iron depletions in shades of gray, and masses of iron accumulation in shades of yellow, brown, or red are in the E horizon of some pedons. The A and E horizons are fine sandy loam, sandy loam, loamy fine sand, or loamy sand.

The Bt horizon-has hue of 7.5YR, 10YR or 2.5Y, value of 5 or 6, and chroma of 3 to 8, commonly with iron depletions in shades of gray, and masses of iron accumulation in shades of yellow, brown, or red. The Btg horizon has hue of 7.5YR to 5Y, or is neutral, value of 5 to 7, and chroma of 0 to or 2, commonly with masses of iron accumulation in shades of yellow, brown, or red. The Bt and Btg horizons commonly are sandy clay loam but range to clay loam or sandy loam in some pedons. Some pedons have subhorizons less than 6 inches thick of sandy clay. Silt content in the control section is less than 30 percent.

The BCg horizon, present in most pedons, has hue of 10YR to 5Y, or is neutral, value of 5 to 7, and chroma of 0 to 2, commonly with iron depletions in shades of olive, and masses of iron accumulation in shades of yellow, brown, or red. It dominantly is sandy loam or sandy clay loam but ranges to clay loam or sandy clay. Some pedons have strata or pockets of contrasting materials.

The Cg horizon has the same colors given for the BCg horizon, or it is a combination of iron depletions and accumulations in shades of gray, yellow, brown, or red. Texture is variable, ranging from sandy to clayey materials. Some pedons are stratified and some pedons have pockets of contrasting materials.

COMPETING SERIES: There are no other known series in this family. Abell, Altavista, Augusta, Bertie, Eunola, Goldsboro, LTnchburg, Ogeechee, Rains, Summerfield, Tetomm, and Yauh~eries are similar soils in other families. Abell, Altavistz, A----~usta, Bertie, summerfield, and Tetotum soils have mixed mineralogy. Eunola, Goldsboro, and Yauhannah soils are better drained and have a matrix of higher chroma in the' control~ section. Lynchburg soils do not have aday decrease of as much as 20 · percent of the maximum within a depth of 60 inches from the soil surface. Ogeechee and Rains soils are gray in 60 percent or more of the matrix between the A or Ap horizon and a depth of 30 inches.

GEOGRAPHIC SETTING: Yemassee soils are on nearly level terraces and broad flats of the lower Coastal Plain. Near the type location the mean annual air temperature is about 65 degrees F.; the mean annual precipitation is about 51 inches; and the freeze-free season is about 243 days.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the similar Ogeechee, and Yatthannah series, plus Bladen, Chisolm, Coosaw, Craven, Eulonia, Hobcaw, and Wahee series. Bladen, Craven, Eulonia, anil-W-'~e soils have a clayey; p~--"~--~e-sxze conlxOl section. C~ and Coosaw soils have an arenic epipedon. Hobcaw soils have an umbrie epiped°,n.

DRAINAGE AND PERMEABILITY: Somewhat poorly drained; slow runoff; moderate permeability. The water table is about 1.0 to 1.5 feet below the soil surface for as much as 4 months during winter and early, spring in most years.

USE AND VEGETATION: Forested areas are dominantly loblolly pine, slash pine, longleaf pine, sweetgum, blackgum, water oak, dogwood, and hickory. Cultivated areas are primarily used for corn, soybeans, small grain, track crops, and pasture grasses.

DISTRIBUTION AND EXTENT: Lower Coastal Plain of South Carolina and possibly North Carolina and Virginia. The series is of moderate extent.

MLRA OFFICE RESPONSIBLE: Raleigh, North Carolina

SERIES ESTABLISHED: Beaufort County, South Carolina; 1975.

REMARKS: The concept of these soils is having a dominant chi'oma of 2 in all layers, except a subsurface or upper subsoil layer with a dominant chroma of 3.

Diagnostic horizons and features recol~ized in this pedon are:

Ochric epipedon - the zone ~om the surface of the soil to a depth of 12 inches (A and E horizons)
Argillic horizon - the zone bom a depth of 12 to 50 inches (Bt, Btgl, and Big2 horizons)
Endosaturation - saturation in all layers to a depth of 90 inches

ML~: 133A, 153A, 153B

ADDITIONAL DATA: Particle-size and pe~ographic data are on file for this pedon.
TABULAR SERIES DATA:

SOI-5	Soil Name	Slope	Airtemp	FrFr/Seas	Precip	Elevation
SC0053	YEMASSEE	0- 2	60- 66	240-260	50- 68	0- 40
SC0117	YEMASSEE	0- 2	60- 66	240-260	50- 58	0- 40

SOI-5	FloodL	FloodH	Watertable	Kind	Months	Bedrock	Hardness
SC0053	NONE	RARE	1.0-1.5	APPARENT	DEC-MAR	60-60	
SC0117	COMMON		1.0-1.5	APPARENT	DEC-MAR	60-60	

SOI-5	Depth	Texture	3-Inch	No-10	Ciay%	-CEC-
SC0053	0-12	LS LFS	0- .0	100-100	5-15	1- 8
SC0053	0-12	SL FSL	0- 0	100-100	10-20	2- 4
SC0053	12-50	SCL CL FSL	0- 0	100-100	18-35	3- 8
SC0053	50-75	SCL FSL SC	0- 0	100-100	12-40	3- 8
· SC0053	75-90	VAR				
SC0117	0-12	LS LFS	0- 0	100-100	5-15	l- 3
SC0117	0-12	SL FSL	0- 0	100-100	10-20	2- 4
SC0117	12-50	SCL CL FSL	0- 0	100-100	18-35	3- 8
SC0117	50-75	SCL FSL SC	0- 0	100-100	12-40	3- 8
SC0117	75-90	VAR				

SOI-5	Depth	-pH-	O.M.	Salin	Permeab	Shnk-Swll
SC0053	0-12	3.6- 6.0	.5-4.	0- 0	6.0- 20	LOW
SC0053	0-12	3.6- 6.0	.5-4.	0- 0	2.0- 6.0	LOW
SC0053	12-50	3.6- 5.5	-	0- 0	0.6- 2.0	LOW
SC0053	50-75	3.6- 5.5	-	0- 0	0.6- 2.0	LOW
SC0053	75-90					
SC0117	0-12	3.6- 6.0	.5-4.	0- 0	'6.0- 20	LOW
SC0117	0-12	3.6- 6.0	.5-4.	0- 0	2.0- 6.0	LOW
SC0117	12-50	3.6- 5.5	-	0- 0	0.6- 2.0	LOW
SC0117	50-75	3.6- 5.5	-	0- 0	0.6- 2.0	LOW
SC0117	75-90					

National Cooperative Soil Survey
U.S.A.

LOCATION ZOAR WV~-PA VA

Established Series
Rev. ART,WFH
07/2001.

ZOAR SERIES

The Zoar series consists of very deep, moderately well drained, slowly permeable soils formed in slackwater deposits. Zoar soils are on terraces. Slopes range from 0 to 30 percent. The mean annual precipitation is about 43 inches and the mean annual temperature is about 53 degrees F.

TAXONOMIC CLASS: Clayey, mixed, active, mesic Aquic Hapludults

TYPICAL PEDON: Zoar silt loam - cultivated. (Colors are for moist soil unless otherwise noted.)

Ap--0 to 8 inches, dark brown (10YR 4/3) silt loam; weak medium granular structure; friable; many fmc roots; neutral; abrupt smooth boundary. (5 to 10 inches thick)

BA--8 to 11 inches, yellowish brown (10YR 5/4) silt loam; weak very fmc subangular blocky structure; ridable; many fine roots; strongly acid; clear smooth boundary. (0 to g inches thick)

Btl--11 to 19 inches, yellowish brown (10YR 5/6) silty clay loam; moderate medium subangular blocky structure; fn-m, slightly plastic, slightly sticky; common fmc roots; thin discontinuous clay films on ped faces; strongly acid; gradual smooth boundary. (5 to 10 inches thick)

Bt2--19 to 23 inches, yellowish brown (10YR 5/6) silty clay; common medium distinct olive yellow (5Y 6/6) and strong brown (7.5YR 5/8) mottles; moderate medium subangular blocky structure; fn'm, plastic, slightly sticky; common fmc roots; thin discontinuous clay films on ped faces; strongly acid; gradual wavy boundary. (3 to 12 inches thick)

Bt3--23 to 38 inches, strong brown (7.5YR 5/8) silty clay; many medium prominent hght olive gray (5Y 6/2) and light yellowish brown (2.5Y 6/4) mottles; moderate coarse subangular blocky structure arranged in coarse prisms; finn, plastic, slightly sticky; few f'me roots; thin continuous clay films on prism faces, thin discontinuous clay films on ped faces; strongly acid; gradual wavy boundary. (8 to 20 inches thick) (Combined thickness of the Bt horizon is 20 to 35 inches)

Cg--38 to 60 inches, gray (10YR 6/1) clay loam; common medium distinct '..s~trong brown (7.5YR 5/8) mottles; massive; firm; very strongly acid.

TYPE LOCATION: Randolph County, West Virginia; 1 mile northeast of village of Elkwater on east side of Secondary Road No. 56.

RANGE IN CHARACTERISTICS: Thickness of the solum ranges from 30 to 50 inches. Depth to bedrock is more than 60 inches. Depth to the base of the argillic horizon ranges from 30 to 50 inches. Rock fragments range from 0 to 3 percent throughout. The particle size control section averages from 35 to 50 percent clay. Unlimed soils are strongly acid or very strongly acid. Mottles with chroma of 2 or less are at depths of 16 to 32 inches.

The Ap horizon has hue of 7.5YR or 10YR, value of 3 through 5, and chroma of 2 through 4. Texture is loam, silt loam or silty clay loam. Uneroded or undisturbed pedons commonly have an E horizon 3 to 6 inches thick with hue of 10YR or 2.5Y, value of 4 or 5 and chroma of 3 or 4.

The BA horizon, where present, has hue of 7.5YR or 10YR, value of 4 or 5, and cb. roma of 4 through 6. Texture is silt loam or silty clay loam.

The Bt horizon has hue of 5YR through 10YK, value of 4 through 6 and chroma of 4 through g. Texture is silty clay or silty clay loam. High and low chroma mottles of are present in the lower part of the Bt horizon.

Some pedons'have a BC horizon that is gray and mottled, 0 to 15 inches thick. Texture is silty clay or silty clay loam.

The C horizon has a hue of 5YR through 10YR value of 4 through 7 and chroma of 1 through 6. Texture is clay loam, silty clay loam, silty clay or clay. Varying is evident in the C horizon of some pedons.

COMPETING SERIES: These are the Craze, Donlonton, Flatwoods, Keyvort and Latham series in the same family. The Cruze soils formed in co-5Ii-~ium or residuum and typ~ntain ~6F~'-ttmn 3 · percent sandstone rock fragments in the control section. Donlonton soils formed in old marine sediment on the Northern Atlantic Coastal Plain, contain moderate amounts of glauconite in the profile, and have texture of sandy clay or sandy clay loam in the Bt horizon. Flatwoods soils is moderately deep to shale bedrock and formed in residuum. Keypon soils formed in Coastal Plain sediments and allow hue of 2.5Y and 5Y in the solum. Latham soils are moderately deep to a paralithic contact and formed in residuum.

The Licking, Tygan and yincent series are in similar families. Licking and Vincent soils have base . saturaUon greater than 35 percent at 50 inches below the top of the argillic horizorr The Tygart soils have evidence of wetness immediately below the Ap horizon.

GEOGRAPHIC SETTING: The Zoar soils are on terraces. They formed in acid slackwater sediments. Slopes are 0 to 30 percent. The climate is humid temperate. Average annual precipitation ranges from'35 to 50 inches, and average annual temperature is from 49 degrees to 57 degrees F.

GEOGRAPHICALLY ASSOCIATED SOILS:-These are the Allegheny, Monongahela and Tygart · soils on terraces, the Ernest and Vandalia soils on colluvial footslopes, and the Berks, Gilpin, Muskingum, Weikert,--W----~'tmoreland, and Upshur soils on uplands. All these so~ s~cept--T~e competing Tygart soils, and the Upshur and Vandalia soils have less than 35 percent clay in the control section. Upshur and Vandalia soils have rock fragments in the control section and have more than 35 percent base saturation.

DRAINAGE AND PERMEABILITY: Moderately well drained; slow to moderate runoff; slow permeability.

USE AND VEGETATION: These soils are mainly used for cropland, pasture or urban uses.

DISTRIBUTION AND EXTENT: Appalachian Plateau of Pennsylvania, Virginia and West Virginia. The series is of moderate extent.

MLRA OFFICE RESPONSIBLE: Morgantown, West Virginia

SERIES ESTABLISHED: Jackson and Mason Counties, West Virginia,'1958.

REMARKS: Some pedons included with Zoar soils in mapping in West Virginia have unconforming reddish clay, lower B and C horizons of 2.5YR or 10R hue.

Diagnostic horizons and features recognized in this pedon are:

Ochric epipedon - The zone from 0 to 8 inches (Ap horizon).

Argillic horizon - The zone from 11 to 38 inches (Btl, Bt2, and Bt3 horizons).

Aquic feature - Mottles with chroma of 2 or less within 24 inches below the upper boundary of the argillic horizon.

SIR: WV0027

National Cooperative Soil Survey
U.S.A.

Appendix B

RECOMMENDED PROCEDURES FOR WATER TABLE MONITORING

Subsurface Site Hydrology As It Pertains
To Wastewater Treatment and Disposal in Virginia
Grant #NA870Z0253-01

Submitted by

Jay F. Conta
Phillip R. Cobb
Gary F. Whitley
Carl D. Peacock, Jr.

Prepared for

Virginia Department of Environmental Quality
Virginia Coastal Resources Management Program

National Oceanic and Atmospheric Administration
Office of Ocean and Coastal Resources Management

December 3, 2001

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December 3, 2001

Recommended Procedures for Conducting a Water Table Study

Submitted to the Virginia Department of Health
Office of Environmental Health Services

This manual serves to develop and provide consistent and uniform methods and terminology to observe, describe, measure, and report water table levels for soil-sites. that potentially may be used for onsite wastewater treatment and disposal. The manual is designed for Virginia Department of Health environmental health specialists and private sector soil and engineering consultants that work in the onsite wastewater treatment and disposal program.

This manual was developed as part of a Coastal Zone Management Grant study entitled, '~Vater Table Study for Nitrate Management and Improved Site Evaluation for Onsite VVastewater Treatment." This cooperative grant was funded by the National Oceanic and Atmospheric Administration and administered by the Virginia Department of Environmental Quality. The Virginia Department of Health, Office of Environmental Health Services received the grant and provided oversight for the study. Duke Price (VDH-OEHS) was project coordinator.

This water table manual was written by Jay F. Conta, Gary F. VVhitley, Carl D. Peacock, and Phillip R. CobbmVirginia Tech Soil Scientists: In cooperation with Virginia Department of Health and Virginia Department of Environmental Quality

The authors wish to acknowledge the many dedicated and professional Virginia Department of Health Environmental Health Specialists who contributed to this project by securing pertinent and viable soil sites for the watertable-monitoring project. Their field assistance and professional curiosity were invaluable to the water table study.

Introduction

Depth to water table or soil wetness features is a major factor in determining soil-site suitability for an onsite wasteWater treatment and disposal system. Depth to water table or soil wetness features not only determines if a soil-site is suitable, but also is a critical factor in how well and for how long a wastewater system will function.

Historically and practically, conventional septic system drainfield performance has been judged successful if wastewater or septic effluent does not break out to the ground surface or back up into household plumbing fixtures or living quarters. Again, from a historical perspective of drainfield performance, probably no state in the United States is exempt from the connotations derived from the old standby slogan "out of site, out of mind." Even today in Virginia (and probably all other states), not too many local and state environmental health professionals get a call from a concerned citizen saying "1 think my BOD is too high," or "My drainfield is functioning fine hydraulically, but come check it for nitrates and viruses." Instead, most official requests from the public to check the "performance" of a septic system drainfield originate because of a hydraulic failure.

Once a conventional wastewater system is permitted and installed, there is a general expectation from the homeowner and the general public that the system will function correctly and indefinitely without any further evaluation or monitoring, other than periodic pumping of the septic tank (which is recommended but not required). This passive expectation makes it important that potential wastewater soil-sites be evaluated as thoroughly as possible for the impact a water table or soil wetness may have on the permitting and functioning of the wastewater system. Protection of public health and groundwater is the ultimate goal.

** The mention of trade names, products, or companies in this report does not constitute an endorsement.

What Is A Water Table?

The concept and definition of a water table has often meant something different to each scientific, environmental, or other user group that uses the term water table. For example, if the user group is geared towards geology, then the definition and concept of a water table may have a geologic slant. The largest user group is the average homeowner in a rural area who has a drilled or bored well for drinking water and other household uses. The homeowner's (and professional well driller's) concept of a water table is how far he/she has to drill or prospect to hit a sustaining yield of potable water. Their definition is also sharpened by how much it cost to dig the well. The average homeowner can rightly be excused from his befuddlement when told by VDH that a septic system drainfield can not be permitted on his property because of a "high water table" at 26 inches below the soil surface. The homeowner knows only too well that he had to pay several thousand dollars for a drilled well that tapped his "water table" at 475 feet below the ground surface.

Ten definitions of a water table and their sources

1. Seasonal Water table - Means that portion of the soil profile where a color change has occurred in the soil as a result of saturated soil conditions or where soil concretions have formed. Typical colors are gray mottlings, solid gray or black. The depth in the soil at which these conditions first occur is termed "seasonal water table." (Virginia Department of Health Sewage Handling and Disposal Regulations, 2000.)

2. Water Table - The upper surface of ground water or that level in the ground where the water is at atmospheric pressure. (Glossary of Soil Science Terms, Soil Science Society of America, 1996.)

3. Perched Water Table - A saturated layer of soil, whiCh is separated from any underlying saturated layers by an unsaturated layer. (Glossary of Soil Science Terms, Soil Science of America, 1996.)

4. Water Table - The surface between the zone of saturation and the zone of aeration; that surface of a body of unconfined ground water at which the pressure is equal to that of the atmosphere. (Dictionary of Geological Terms, Robert L. Bates and Julia A. Jackson, 1984.)

5. Water Table - The zone of saturation at the highest average depth during the wettest season; it is at least six inches thick and persists in the soil for more than a few weeks. (Federal Manual for Identifying and Delineating Jurisdictional Wetlands, 1989.)

6. Water Table - The level of the surface of the groundwater. (Septic Tank Systems Recommendations for Domestic Effluent Treatment and Disposal From A Single 'Dwelling House. National Standards Authority of Ireland. EOLAS, 1991)

7. Water Table - The surface of the groundwater. (Soil Science Simplified. Milo I. Harpstead, Francis D. Hole, and William F. Bennett, 1988)

8. Perched Water - Groundwater that occurs above the water table; "perched" above a layer of unsaturated rock or soil. (Threats to Virginia's Groundwater. Diana L. Weigmann and Carolyn J. Kroehler, 19887)

9. Perched water table--means a saturated zone, generally above the natural water table, as identified by drainage mottles caused by a restrictive horizon. (North Carolina On-site Wastewater Management Guidance Manual (J.A. Arnold et al., 1996)

10. Seasonal High Water Table -- The highest level of a saturated zone in the soil in most years. (Soil Survey of Northampton County, Virginia. Phillip R. Cobb and David W. Smith, 1990.)

Most of the definitions are similar in concept but have some wording differences. The two definitions that stand apart from the others are those used by the Virginia Department of Health and the North Carolina Division of Health, On-Site Wastewater Section. Their definitions, in relation to onsite wastewater treatment and disposal, are focused on the part of the soil that has concretions and/or gray or black colors caused by saturation (Virginia); and drainage mottles caused by a restrictive horizon (North Carolina). No other definition mentions or requires that gray colors or drainage mottles be present in order to have a water table. Identifying these gray/black colors and drainage mottles will determine if a site is suitable for an onsite wastewater system, and the depth that drainfield trenches will be installed. No doubt most other states use a similar concept of a water table for their own onsite wastewater treatment and disposal programs. Also, the USDA Natural Resource Conservation Service (formerly the Soil Conservation Service) has always used the presence or absence of gray mottles and gray soil colors to describe and classify soils to the most detailed level (soil series) in the Cooperative Soil Survey Program in the United States.

What is a workable definition of a water table for onsite wastewater treatment and disposal? Can there be just one definition or concept that will suffice for all user groups? Probably not. In the ten definitions above, eight are mostly concerned with free water that is present in voids, macro and micro pores, animal channels, cracks, and joints in the soil and rock matrixes. The eight sources make only perfunctory references to soil/rock characteristics or properties.

The Virginia Department of Health is concerned with the concept and definition of water table and soil wetness that impacts the permitting and long-term performance of onsite wastewater treatment and disposal systems. Any definition or conceptual framework of a watertable should be grounded in science and practical application. Accordingly, a recommended definition of a water table and soil wetness in this manual will be: That portion of the soil-geologic continuum where redoximorphic features have formed by reduction, oxidation, and translocation of iron and manganese compounds; and/or, that portion of the soil-geologic continuum that is saturated with groundwater year-after-year in the wettest seasons, and the saturation can be observed and measured over defined space and time.

What is to be tested?

When trying to decide if a watertable study is needed, what soil-site characteristics and properties are to be tested, and how should the results be interpreted? A brief discussion of various watertable and soil wetness features follows below. In addition, preferred terminology for soil wetness and a watertable is indicated.

A soil is wet when we can actually see and measure free water, water not held by tension or suction, in the soil. This type of soil wetness is commonly observed in Virginia wet soils during winter and spring by boring an auger hole or digging a backhoe pit to a depth where free water begins to seep into the hole. Technically, this free water may not be the actual watertable, which may be lower in the soil. According to Keys to Soil Taxonomy (1999), "Problems (interpreting the watertable) may arise, however, in clayey soils with peds, where an unlined auger hole may fill with water flowing along faces of peds while the soil matrix is and remains unsaturated (bypass flow). Such free water may incorrectly suggest the presence of a watertable, while the actual water table occurs at greater depth." Even though this free water flowing along ped faces may not be the actual, technical watertable, it can and does impact the performance of a septic system drainfield and other onsite wastewater systems, when it is present year-after-year for sustained period. The key to acknowledging and separating this type of soil wetness from transient soil wetness caused by a specific storm event is that predictive and repetitive factors can be tied to the ped-flow soil wetness.

Soil Taxonomy (1999) has a general provision for soils that have seasonal wetness but are not gray or reduced. These soils are labeled as Oxyaquic and must be saturated in one or more layers within 40 inches of the mineral soil surface for either or both (1) 20 or more consecutive days, or (2) 30 or more cumulative days. This 20-day consecutive and/or 30-day cumulative requirement could be met by many Virginia soils, particularly in the Coastal Plain, that do not have gray mottles (redox depletions of chroma 2 or less), but do have chroma 3 and 4 mottles and free water in the soil during winter and spring. The Virginia Sewa,qe Handlin.q and Disposal Re.qulations (1982 and 2000) state that the presence of free water in a soil may be grounds for rejection of a site for a septic system drainfield.

The other major indication of soil wetness is the presence of redoximorphic or soil wetness features that formed or are forming as a result of current wetness and saturation in soils. Other features to measure and interpret include: relict or historic mottles; parent material mottles; lithochromic soil colors inherited from parent rock; and wet soils that have minimal to no redoximorphic features.

Redoximorphic Features

In the early 1980's the National Resource Conservation Service, which has nationwide responsibility for mapping and classifying soils, recognized a need to have better and more qualitative methods to describe "aquic conditions" and soil wetness features (Vepraskas, 1992). Historically, soil wetness features had been called mottles, coatings, and concretions, and unless stated otherwise, were considered to be products of soil wetness. The NRCS established a committee, (International Committee on Soils with Aquic Soil Moisture Regimes (ICOMAQ), to develop ideas and recommendations for better describing soil wetness features. The term "redoximorphic features" was borne out of this committee. In addition, one of the committee members, Dr. Mike Vepraskas of North Carolina State University, compiled a clear and concise, illustrated publication entitled "Redoximorphic Features for Identifying ^quic. Conditions," Technical Bulletin 301. This publication is an excellent primer for identifying and describing redoximorphic features and the interested reader is advised to consult Technical Bulletin 301 for more in-depth information.

Redoximorphic features (redox features) is the recommended term. in this Virginia Department of Health watertable manual and is defined as: "Soil properties associated with wetness that result from the reduction and oxidation of iron and manganese compounds in the soil after saturation with water and desaturation, respectively" (Glossary of Soil Science Terms, 1996). Redox features are essentially synonymous with soil wetness features but are more descriptive and encompassing.

Watertable studies may be conducted in soils with or without redoximorphic features. Virginia's Sewa.qe HandlinR and Disposal Re.qulations (2000) require that conventional drainfield trenches maintain a separation distance from the bottom of the trenches to a watertable or redox features. From 1982 to July 2000, this sliding scale separation distance was based on soil texture and estimated percolation rate at the trench bottom. The faster the percolation rate, the closer trench bottoms could be to a water table or redox features. After July 2000, all drainfield trench bottoms will maintain a minimum of 18 inches to a watertable, unless the effluent is pretreated, which allows for a 12-inch separation distance.

Formation of Redoximorphic Features

Redoximorphic features form in the soil by the pedological-geochemical processes of reduction, oxidation, and translocation of iron and manganese compounds (Vepraskas, 1992). Very simply, reduction occurs when the soil becomes saturated and oxygen deficient; oxygen consuming bacteria reduce the iron and manganese minerals; the iron and manganese minerals chemically dissolve or go into suspension in the soil-water state; and the iron and manganese minerals move or are translocated with the soil-water gradient. Iron and manganese oxides are the major colorers in the soil. In their oxidized states, iron gives the soil particles a reddish or brownish color and manganese imparts a black color. When iron and manganese minerals are reduced, they are stripped and removed from the soil particles, which results in the sand, silt, and clay particles having a gray or pale color.

Oxidation occurs when the iron and manganese compounds that are dissolved or suspended in the soil-water state encounter oxygen or aerobic conditions in the soil. These oxygenated conditions can be present in root channels, pores, along structural ped faces, and in the general matrix of the soil. The iron and manganese compounds are precipitated and revert to their oxidized form, again imparting a reddish, brownish, or blackish color to soil particles and other concentrations. In many soils, especially moderately well drained, somewhat poorly drained, and poorly drained soils, soil colors are not uniform but are mottled and mixed. This indicates that reduction and oxidation have both occurred and redox processes should be viewed as continuously dynamic.

'Reduction and oxidation are complex processes in the soil. All parameters have to be present and probably optimal in the soil for redox features to be formed. In fact, where redox features are present in a soil, the only conclusion that can be made with certainty is that conditions were right for redox features to form. In lieu of actual water table data, mere presence of redox features does not allow for much precision for interpretation of water table duration. In optimal laboratory conditions, Meek et al., (1968), indicated that reduced colors could form within 10 days of submergence. Vepraskas and Guertal (1992) estimated that the time dynamic required for formation of a 2 mm-thick iron depletion around a root channel could vary from less than one year to more than 100 years. For practical reasons, the Virginia Department of Health 2000 Regulations state that "gray and/or gray mottlings indicate seasonal water tables for at least three weeks duration." This short duration also falls neatly into the oxyaquic soils slot in soil taxonomy that requires 20 consecutive days or 30 cumulative days of saturation.

Very simply, if redox features are viewed as part of an equation, then the equation might read: Soil Redox Features = Saturation and Desaturation + Iron and Manganese + Reducing Bacteria + Soil Temperature + Organic Compounds + Time. That is, redox features (especially chroma 2 or less redox depletions) will or can form when all processes and parameters are at an optimum. Conversely, if one or more of the input variables is lacking or not optimum, redox features may not form even though the soil may be wet. In theory, each variable can be viewed as independent; however, the more realistic view would consider them as dependent variables similar to the variables in soil formation (Buol et al., 1973).

Other Soil Features That May Trigger the Need for a Watertable Study

Groundwater in the soil that is present year-after-year during the wet seasons and redoximorphic features formed by reduction and oxidation of iron and manganese are physical factors that confirm soil wetness. There are other physical features in the soil that may require a watertable study to confirm or disprove current day soil wetness. These include, but are not limited to, relict or historic mottles; parent material mo.Eles; lithochromic soil colors inherited from parent rock; and seasonally wet soils devoid of gray redox features, but have abundant chroma 3 and 4 mottles. Each is briefly discussed.

Relict and Historical Mottles

Relict or Historic mottles do exist in soils. Unfortunately, a reasonable discourse in the soil community about these features is often short-lived because it is feared one side will see nothing but '.'relicts", while the other side will never acknowledge "relicts." Soil Taxonomy(Soil Survey Staff, 1999) indicates that there have been significant climatic changes during geologic time and soil features present today may have formed under different climatic regimes; and "such soils have relict features that reflect the former moisture regime .... "

One obvious setting for relict mottles in the field is where extensive downcutting and dissection has taken place across former level and nearly level landforms. These former subdued landforms may have had watertable and redox processes close to the soil surface. As downcutting proceeded over geologic and pedologic time, the areal or regional watertable was lowered in the wet soils and relict mottles are left "high and dry." This is beSt observed in the Virginia Coastal Plain in areas where a major river such as the Rappahannock meets the tidal estuaries along the Chesapeake Bay. Today, some of these highly dissected areas have gray mottles in soils that are on steep and very steep sideslopes. These gray mottles were probably formed when the area was flatter and wetter. Many of these relict mottles are in fine-textured soil materials and hodzons that have current-day slow or restrictive permeability. It may be necessary to a conduct Ksat test as well as a watertable study to determine ultimate suitability for a drainfield in these heavy-textured soil materials.

Parent Material Mottles and Lithochromic Soils

Parent material mottles are most often in Piedmont residual soils with underlying saprolite and weathered bedrock. Parent material mottles can be white, red, gray, black, green, pink, and any other color associated with the saprolite and parent rock. In many Piedmont soils weathered from granite or granite gneiss, it is common to have chroma 2 or less mottles, streaks, and soft clayey plugs and masses that are weathering stages of feldspar and kaolinite minerals. These types of mottles are not typically related to soil wetness. However, as with relict mottles, parent material mottles and the clayey plugs and masses may be in fine-textured soil materials with slow or restrictive permeability. A ksat test may be needed instead of a watertable study.

Soils that are the same' color throughout the profile as the underlying parent materials and rocks are generally called lithochromic. These soils are commonly reddish or black in color. The color of the soil may not be reflective of the current day drainage and permeability. The two best examples of this are the Triassic reddish brown soils weathered from sedimentary red beds, and the Piedmont soils weathered from graphite 'schist.

In the Triassic soils, it is typical to have only the A or Ap horizon be slightly different in color than the underlying Bt, C, Cr, and R horizons, which are usually reddish brown. Reddish brown soils are generally considered to be well drained because of the oxidized colors in the Bt horizons. However, the red bed soils have inherited their reddish brown colors from the underlying parent rocks. Soil wetness features in these reddish brown soils may consist only of chroma 3 and 4 mottles and manganese oxide coatings on rock faces.

Graphite schist in the crystalline rocks of the Piedmont commonly weathers to gray and black soils. The profile may be gray or black from top to bottom. These dark colors Can easily mask redox features and minimize other soil wetness features that may be present in the soil, especially on Iow relief and slightly concave landforms. Because soil wetness may be masked, it is critical that drainfields be sited only on suitable upland landforms. Or, the other way to view it is, avoid marginal landforms and landscape positions. A suitable landform will take away or help minimize one of the potential limiting variables in lithochromic soils.

Finally, if there is doubt about the current day wetness of lithochromic soils, a water table study may be needed.

Wet Soils With Minimal Redox Features

These are the toughest soils to deal with in the onsite wastewater treatment and disposal program. The soils typically are wet during some part of the winter and spring, but have minimal redox features. The soils commonly have chroma 3 and 4 mottles, but no chroma 2 or less redox depletions. Free water rapidly seeps into an auger boring or backhoe pit. The soils can be any texture, but often the free water in a profile is perched on a restrictive soil horizon. The soils are often on lower or "dependent" landforms such as a long toeslope or footslope.

Some methods to help evaluate and work with these "oxywet" soils are to conduct a standard two to three year water table study; visit the site over a three week period and bore profiles each week to document free water in the soils; have a cutoff limit for presence of chroma 3 and 4 mottles (perhaps many, which is 20% or more of the surface area); do not have a restrictive horizon within 30 inches of the soil surface; do not site any drainfield on a marginal landform or landscape position; and do not have an additional site limitation beyond the "oxywet" conditions;

Methods and Procedures for Planning and Conducting Water Table Studies

A detailed plan for conducting a water table study should be developed by the interested party and ultimately reviewed by the appropriate county or district health department. Reasons and justifications for conducting the watertable study, construction and installation standards, and minimum requirements for site approval should be agreed to by all parties, preferably in a meeting. Submission of the plan should allow ample time for YDH review before the study begins. Normally this is 30 days, but less time is allowed if the proposed study is getting close to the winter and spring seasonal water tables, and VDH has conducted a timely review. Provisions will be in place prior to the start of the watertable study that allow VDH personnel to check watertable levels at any time during the study period.

Site Location and Map Standards

The water table study plan should include a site location on a surveyed plat with contour intervals, if available. As a minimum, the overall study site and individual well locations should be delineated on a standard USGS 1:24,000 topographic quadrangle. An alternative method can be to locate the study site and wells on a topographic map that is generated by CD-ROM or other computer aided programs that contain topographic coverage of Virginia. In any case, the topography of the study site and wells should be of sufficient detail that allows for determination of elevation and the relative landform or landscape position.

Soil and Site Descriptions

The study plan should provide detailed soil descriptions that conform to the standards of the National Cooperative Soil Survey and/or approved standards set forth by Virginia Department of Health. Soils should be classified to the series or series-like level (example Munden-like) using existing soil survey information, or rough field classifications. The soil descriptions should be located near watertable well locations in order that watertable data can be correlated with soil morphological features. Soil profile descriptions can be made using a hand auger or a backhoe pit, as long as the pit does not affect the local watertable hydrology associated with the monitoring well. If backhoe pits are used, more detailed soil descriptions (soil structure, horizon boundaries, etc.) should be provided.

Water Table Study Components and Standards for Manual Monitoring Wells

1. Number of Monitoring Wells

a. Individual Lot or Site: A minimum of three monitoring wells should be located in any proposed onsite wastewater treatment and disposal area. If a reserve area is required and is. contiguous to the proposed onsite area, one of the three wells may be in the 'reserve area. If a required reserve area is not contiguous to the proposed onsite area, two additional monitoring wells should be located in the reserve area.

b. Subdivisions and Mass Drainfields: A plan should be submitted showing the location of wells with justification for the number and location of wells. If agreed to by VDH, monitoring wells may be placed in selected soil areas that represent the wettest soil morphologic features and local, hydrology throughout the subdivision or mass drainfleld areas.

c. Use of Soil and Site Conditions for Well Locations: For all water table studies, one or more monitoring wells must be located in what is considered to be the wettest portion of any proposed onsite wastewater area, based on landform and soil morphologic features.

2. Well Construction Standards for Manual Wells

a. The monitoring well should be bored using a soil auger or comparable boring instrument with efforts made to minimize smearing and compaction of the sidewall soil materials (especially the bottom 18 inches) and basal area of the hole. Use of a power auger for boring a hole is allowed, but compression and smearing of the sidewall soil materials may limit the reliability of the' monitoring well.

b. The well should be cased with schedule 40 PCV pipe with an inside diameter of 1.5 to 3.0 inches. The top of the pipe should be covered with a threaded PCV cap that allows for easy observation, but also can be tightened to minimize vandalism or tampering. The lower twelve inches of the pipe that are in contact with a presumed water table should have narrow slits 1/8 to 114 inch wide, or drilled holes 1/8 to 1/4 inch in diameter.

c. The borehole shall have a minimum annular spacing of 1.0 to 3.0 inches. Adequate annular spacing is necessary to pour pea gravel and grout between the PCV pipe and bore hole.

d. The annular space should be backfllled with clean pea gravel so that all the slits and ddlled holes in the P¥C pipe are encased in the porous pea gravel. Then, six (6) more inches of pea gravel should be added above the encasing depth. The remaining annular space should be grouted to the surface with neat cement or bentonite. It is best to have the bentonite grout stop at 2 to 4 inches below the ground surface, and then backfill to the surface with fine textured soil material that does not excessively shrink, crack, or swell dudng moisture flux. Avoid having bentonite on the soil surface; it is very messy and adhesive. A collar should be made at the surface around the monitoring well to minimize surface water collecting and entering around the well. Careful installation and grouting is cdtical to the collection of meaningful data. Improper installation or grouting may result in the site appearing wetter than it actually is.

e. A reference level should be established from which all measurements are made. The reference level and measurement technique must allow for accurate measurement of the depth from the surface to the water level within plus or minus one inch.

3. Depths of VVells

a. For sites without apparent restrictions, the wells should be placed at a depth which is eighteen (18) inches below the total separation distance required by the regulations or at the contact with bedrock or Cr horizons, whichever is shallower.

b. For sites with an apparent restrictive horizon, one well should be anchored into the top of the restrictive horizon, and another well extending to the depth required in 3 (a), unless there is less than eighteen (18) inches difference in the two depths.

c. For sites where the drainfield is proposed to be placed below an apparent restrictive horizon, one well should be placed at the depth of the top of the restrictive horizon such that the well does not penetrate the restriction. Another well should be placed eighteen (18) inches below the proposed depth of the drainfield trenches.

d. When wells are placed at multiple depths each pair of wells required by (a), (b), and (c) should be considered as one well location with respect to meeting the requirements of I (a), (b), or (c) of this manual.

4. Annual Observation Pedods

For the purpose of determining minimum depth of a seasonal watertable, it is not necessary to observe water table levels on a year round basis. Evaluation of existing water table data along with climatic and anecdotal information shows that sustained high water table levels are far more likely to occur dudng mid-winter to mid-spring that at any other time of the year. Periods of high water tables can occur at other times of the year (usually associated with tropical storms and hurricanes) but are sufficiently anomalous and infrequent that it would be impractical to be considered in siting a drainfield. Consequently, this manual recommends that the annual observation period for water table studies be from December through May.

5. Frequency of Observation

During the annual observation period, manual monitoring wells should be observed a minimum of two (2) times per week at an interval of two (2) to four (4) days, not to exceed four (4) days between observations. The interval between observations will be used as the time period represented by each observation in determining the duration of a seasonally high water table. (For example, with a four (4) day interval, each time a water table is measured within the minimum separation distance as specified by the regulations, a period of four (4) days of unacceptably high water table levels would be recorded towards the maximum consecutive or cumulative total allowed in 7 (a) and (b) below). As a result, in soils suspected to have rapidly fluctuating water tables, a one (1) to two (2) day observation interval may be helpful in determining the actual time an unacceptably high water table is present.

The frequency of monitoring in water table studies may be changed during the study when there is mutual agreement between the client and VDH.

6. Length of Study

The water table study should be conducted for a minimum of two (2) to three (3) annual observation periods. Each observation period may have a range from eighty to one hundred twenty percent (80 to 120%)of average precipitation. When relevant, distribution of precipitation may be presented for consideration of how it affected wetness at the site. The observation study may be ended at any time after the maximum cumulative or consecutive time period of higher than allowed water table levels as specified in 7 (a) and (b) has been exceeded.

If practical, precipitation gauges may be used at each site to record selected intervals and total precipitation to correlate with water table levels. However, precipitation infOrmation doeS not have to be site specific and can be obtained from the closest National Oceanic and Atmospheric Administration (NOAA) approved weather station. The data source should reflect the general climatic conditions at the water table sites. For example, don't use a Ridge and Valley weather station for a monitoring site across the mountains in the Piedmont.

Other sources of precipitation data can include university research stations, media weather stations, U.S. Geologic Survey stations, municipal water and sewer stations, published soil surveys, and Virginia climatologic stations.

7. Acceptable Water Table Levels

a. Annual Cumulative Days

The seasonal high water table should not be above the minimum required depth as specified by the Sewage Handlinq and Disposal Regulations and agreed to in the study proposal for more than thirty (30) cumulative days during any one annual monitoring period.

b. Annual Consecutive Days

The seasonal high water table should not be above the minimum required depth as specified in the Regulations and agreed to in the study proposal for more than twenty (20) consecutive days. This should be calculated by adding the number of consecutive days when water table levels were present. When two consecutive readings show the water table was shallower than the minimum required depth, the day before the first reading and the day after the second reading and all intervening days shall be counted as days where the water table levels were above the required minimum depth.

8. Reportin.q and Notification

a. Reporting

(1) Copies of the water table observation data and the precipitation data shoUld be submitted to the local health department within fourteen (14) days of the end of each month of Observation.

(2) Within thirty (30) days of the end of each annual observation period, a report should be submitted to the local health department summarizing the water table monitoring. The report should relate data to the water table observation and precipitation data to maximize cumulative and consecutive days above the minimum depth required by the Regulations. In addition, the report should state the percent of normal precipitation that occurred from December through May.

(3) A final report should be submitted to the local health department within sixty (60) days of completion of the study. The report should include all water table and precipitation data and appropriate data summaries. The report should also discuss the overall results of the study with respect to required minimum depths to water table levels, percent of normal precipitation, and cumulative and consecutive days observed above the minimum 7 (a) and (b).

b. Notification

The owner or. his consultant should notify the local health district within ten (10) working days when'the observed water table level in any monitoring well has remained above the minimum required depth in excess of the consecutive or cumulative time limits specified in 7 (a) or (b).

Water Table Study Components and Standards for Automated Monitoring Well~

1. Number of Automated Monitoring Wells

   a. Individual Lot or Site: A minimum of three monitoring wells should be located in any proposed onsite wastewater treatment and disposal area. If a reserve area is required and is contiguous to the proposed onsite area, one of the three wells may be in the reserve area. If a required reserve area is not contiguous to the proposed onsite area, two additional monitoring wells should be located in the reserve area.

   b. Subdivisions and Mass Drainfields: A plan should be submitted showing the location of wells with justification for the number and location of wells. Several of the monitoring wells should be placed in selected soil areas that represent the wettest soil morphological features and local hydrology throughout the subdivision or mass drainfield areas.

   c. Use of Soil and Site Conditions for Well Locations: For all water table studies, one or more monitoring wells must be located in what is considered to be the wettest portion of any proposed onsite wastewater area, based on landform and soil morphologic features.

2. Well Construction Standards for Automated Wells

   a. A six to eight inch diameter post hole should be cut three to five inches deep at the surface of the proposed well site. The auger hole for a WL-20 well should be centered in the posthole and bored using a four-inch soil auger to minimize smearing and compaction of the sidewalls. A WL-40 well may need a five-inch diameter hole for proper placement. The well should be installed when the soil is moist or dry to prevent smearing and compaction of the sidewalls.

   b. The well.casing from Remote Data Sensing, Inc., was set to their standards and requirements. Pipe diameter of the WL-20 is 1.9 inches and the WL-40 has a 3.5-inch diameter. A slot width of 0.01 inch was standard on both pipes. Slot spacing is incorporated into their product. Other data logger companies, such as INFINITIES USA, INC. DATA LOGGERS of Florida, specifies their three-inch schedule 40 PVC for use with their product.

c. The well casing or bottom section of the data logger should be lowered into the bore hole and positioned in the center of the hole. The opening at the top of the casing should be covered with a plastic bag or at least a hand to prevent pea gravel or bentonite and sol material from being inadvertently dropped into the well casing.

d. There should be 1.0 to 3.0 inches of annular space between the bore hole and the well casing. Proper annular spacing is necessary to backfill clean pea gravel and bentonite in the annular spacing around the well. The annular space should be backfilled with clean pea gravel so that all the slots are encased in the porous pea gravel. During the backfilling process, a measuring tape may be lowered into the annular space to check the depth of the gravel. Tamp the gravel a little to ensure that it settles. The remaining annular space should be grouted to the surface with neat cement or a bentonite product. When using bentonite, pour water onto the top of each handful of bentonite after the material is dropped into the annular space ring. The bentonite grout should stop at 2 to 4 inches below the soil surface. A fine textured soil material that does not shrink or swell should be used as a capping material to backfill to the soil surface. The soil material should be lightly tamped after backfilling. Bentonite material left exposed at the soil surface is very messy and strongly adheres to almost everything. A collar should be made at the surface around the monitoring well to minimize surface water collecting and entering around the well. Careful installation and grouting is critical to the collection of meaningful data. Improper installation or grouting may result in the site appearing wetter than it actually is.

e~ Each of the automated data logger companies has a reference level established on their respective monitoring well. The well unit should be installed into the soil flush to the reference level. Infinities USA attaches a "Zero Mark" label and RDS attaches a label with "Calibration Point" as their reference level. A measuring tape may be inserted into the hole while boring to make sure the hole depth correlates to the depth of installation label or calibration point. The calibration point should be level with the soil surface.

3. Depths of Wells

a. RDS data loggers are available in three lengths; a 20-inch, 40-inch, and 80-.inch. Having only three available lengths does not offer the versatility of a · manual well since manual well lengths can be cut to fit the situation. When planing a water table study, carefully select the WL length that covers the soil depth that is critical to the study. Monitoring wells from Infinities USA allow for any monitoring depth to be used up to eighteen (18) feet.

b. For sites with an apparent restrictive horizon, one well should be anch'ored 2' to 4 inches into the top of the restrictive horizon. A second well extending through the restrictive horizon should be installed.

c. When two (2) wells are placed at multiple depths to identify restrictive horizons, the two wells should be counted as one well location with respect to meeting the requirements of 1 (a), (b), or (c) in these water table recommendations.

4. Annual Observation Periods

For the purpose of determining minimum depth of a seasonal watertable, it is not necessary to. observe water table levels on a year round basis. Evaluation of existing water table data along with climatic and anecdotal information shows that sustained high water table levels are far more likelY to occur during mid-winter to mid-spring that at any other time of the year. Periods of high water tables can occur at other times of the year (usually associated with tropical storms and hurricanes) but are sufficiently anomalous and infrequent that it would be impractical to be considered in siting a drainfield. Consequently, this manual recommends that the annual observation period for water table studies be from December through May. However, automated monitoring wells may be programmed to take year around readings.

5. Frequency of Observation

During the annual observation Period, it is recommended that automated monitoring wells be programmed to record water table levels two times a day. Once a recording interval is selected, it should not be changed during the study. Changing the recording interval significantly increases the degree of difficulty during data transformation.

6. LenRth of Study

The water table study should be conducted for a minimum of two (2) to three (3) annual observation periods. Each observation period may have a range of 80 to 120% of average precipitation. When relevant, distribution of precipitation may be presented for consideration on how it affected wetness at the site. The water table study may be ended at any time after the maximum 'cumulative or consecutive time period of higher than allowed water table levels as specified in 7 (a) and (b) has been exceeded.

If practical, precipitation gauges may be used at each site to record selected intervals and total precipitation to correlate with water table levels. However, precipitation information does not have to be site specific and' can be obtained from the closest National Oceanic and Atmospheric Administration (NOAA) approved weather station. The data source should reflect the general climatic conditions at the water table sites. For example, don't use a Ridge and Valley weather station for a monitoring site across the mountains in the Piedmont.

Other sources of precipitation data can include university research stations, media weather stations, U.S. Geologic Survey stations, municipal water and sewer stations, published soil surveys, and Virginia climate stations.

7. Acceptable Water Table Levels

a. Annual Cumulative Days

The seasonal high water table should not be above the minimum required depth as specified by the Sewa,qe Handling and Disposal Re.qulations and agreed to in the study proposal for more than thirty (30) cumulative days during any one annual monitoring period.

b. Annual Consecutive Days

The seasonal high water table should not be above the minimum required depth as required in the Regulations and agreed to in'the study proposal for more than twenty (20) consecutive days. This should be calculated by adding the 20 days or more of consecutive days when water table levels were present. When two consecutive readings show the water table was shallower than the minimum required depth, the day before the first reading and the day after the second reading and all intervening days shall be counted as days where the water table levels were above the required minimum depth.

-8. Reporting and Notification

a. Reporting

1. Copies of the water table observation data and the precipitation data should be submitted to the local health department within fourteen (14) days of the end of each month of the observation period.

2. Within thirty (30) days of the end of each annual observation period, a report should be submitted to the local health department summarizing the water table monitoring. The report should relate the new data to the water table observation and precipitation data to maximize cumulative and consecutive days above the minimum depth required by the Regulations. In addition, the report should state the percent of normal precipitation that occurred from December through May.

3. A final report should be submitted to the local health department within sixty (60) days of completion of the study. The report should include all water table and precipitation data and appropriate data summaries. The report should also discuss the overall results of the study with respect to required' minimum depths to water table levels, percent of normal precipitation, and cumulative and consecutive days observed above the minimum 7 (a) and (b).

b. Notification

The owner or his consultant should notify the local health district within ten (10) working days when the observed water table level in any monitoring well has remained above the minimum required depth in excess of the consecutive or cumulative time limits specified in 7 (a) or (b).

Additional Notes on Data Loaner Use

1. The installation of a manual well' is recommended when using any automated monitoring well. A manual well helps to prevent loss of data, monitoring time, improper downloading and vandalism.

2. When planning a data logger installation at a site, and the last two inches of the design length are critical to the water table study, install the next longer length of data logger. For example, if information is needed at the 18-20 inch soil depth, install a WL-40 data logger instead of a WL-20. If the 38-40 inch depth in the soil is critical, install a WL-80 instead of a WL-40. Often the bottom of the data logger casing will accumulate one to two inches of fine soil material. The fine soil material will hold moisture that may produce a false positive (water table reading) reading.

3. Before installing the battery in the data logger, bend a paper clip and rattle or shake it against the battery connections in order to reduce static buildup that may occur in Remote Data Systems, Inc., data loggers. Use a voltage meter, such as Radio Shack's LCD Digital Multimeter to check static resistance levels. Install the battery upside down in the battery socket for a few seconds, then install the battery correctly. This is another method suggested to reduce static charge. Use the meter to measure the voltage of the new battery and record the date and measurement. During each site visit or once a month the voltage level should be checked and recorded. Replace the battery when voltage levels measure 1.50 or 1.51 volts. On the side of the battery, use a magic marker and write the date of installation. Different data logger units consume battery power at different rates. Frequent attention to battery power prevents the loss of water table data.

4. Record the time of installation from the data logger and your watch. Compare the times when downloading readings from the data logger. The time on the data logger is impo .rtant because it will vary from your watch sometimes by an hour or more. Data may be lost when being downloaded to the HP-48 calculator, and the data logger takes a programmed or scheduled reading at its reading time.

5. Record serial number of well, type of well, the depth of the well, time and date of installation for reference. The date is recorded so the actual beginning time for reference. Improper programming of the unit may provide an incon'ect date. The data and time are also used to identify the last date of the old data if used data loggers are used for the water table study. It is recommended that new data .loggers be purchased. The serial number identifies the individual data logger during data transformation process.

6. In lawn or field area, drive three stakes in a triangle around the monitoring well to reduce or prevent lawn mower and weed whacker damage to the unit.

7.. Camouflage the monitoring wells will help prevent vandalism and tampering. There are many camafloughe products that can be used, as well as natural limbs and brush at the site.

8. Once each month, auger a hole in the area of the monitoring wells to visually verify soil wetness versus the automated monitoring well reading.

9. While taking a downloading or reading with the HP-48 calculator, cover the data logger, calculator screen and your head with a dark towel or jacket. Too much sunlight and the data logger will not transfer readings between the HP-48 calculator and data logger. Be sure to have the unit facing away from the sun while taking a reading. Kneel on one knee to steady yourself when taking a download reading.

10. When downloading data at the monitoring site and "SO-" appears on the HP-48 calculator screen, it means the reading was incorrect. Think of it as a "strike out." There may be several reasons for the SO- reading. Improper programming, weak battery, and too much sunlight may effect the readings. Or, it may be the way the HP calculator wiggled in your hand dudng the downloading. Since the data loggers are assembled by hand, there is not always perfect alignment between the HP-48 eye and the data logger eye. Think of the opening or eye as a clock and move the HP-48 around the opening in the following pattern; center, 9:00, 12:00 or 3:00. One of the readings will usually be correct. Remember to look for the SO- after each reading to know if you have taken an incorrect reading. Experience with one data logger indicated the well would record only at the 9:00 position; therefore make a mental or written for the next site visit.

11. The unit should be cleaned twice a year to maintain quality downloads. Gently pull the top unit section out of the PVC sleeve and wipe it with a soft Cloth. Use Q-tips with alcohol to clean the eye of the unit carefully. In dusty areas the unit may benefit from more frequent cleanings. Directions are provided in the RDS manual and web site.

12. When installing a data logger, stop the bentonite grout several inches below the soil surface. BentOnite (bentonite clay) will adhere to anything that it comes in contact with. Placing a couple of inches of soil over the bentonite keeps moisture in and prevents a mess.

13. Carry an old car mat, piece of plastic, or something similar, that is waterproof to kneel on when taking a download at a site. It helps keep clothes clean and protects the HP-48 from bentonite and rain.

14. When removing a unit, excavate around the unit with a sharp shooter shovel. Use an auger or posthole digger to remove soil and grout material from along the side of the unit. Removing the material will allow the unit to be pulled straight up.

15. After extraction allow the material to dry on the PVC sleeve section of the unit then use a knife .or ax blade to scrape off the benseal material. The remaining material may be rubbed off with a rough cloth. At any time the unit may be taken to the car wash and use the pressure spray to clean off the casing. Be sure to flush out the inside of the casing.

16. Purchase a hard case for the HP-48 calculator. A hard case prevents the keys from being inadvertently pushed to misdirect the calculator to the wrong program screen, which is often difficult to correct. If you get on the wrong screen, telephone RDS and they will quickly direct you back to the correct program screen on the HP-48.

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OPTICAL READER

· WATERPROOF
MICROPROCESSOR &:
BA'FI'ERY

ZERO POINT
WL-40

FINISHED GRADE

BENTONITE PELLETS

12" l'

WELL SCREEN SECTION
ALL SLOTS 0.01"

47"

6" DIA. HOLE

'40"

NO. 1 SAND
OR PEA GRAVEL

END OF
PROBE

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and Louis Berger & Associates, Inc.

Delaware Department of Transportation

LOCKABLE CAP

FINISHED GRADE

BENTONITE PELLETS

24" (MIN)

2" I.D. SCH. 40 PVC RISER WITH FLUSH THREADS

VARIES

6" DIA. HOLE

35"

2" I.D. SCH. 40 PVC SCREEN SLOT SIZE NO. 10

NO. 1 SAND OR PEA GRAVEL

TYPICAL
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Appendix C

Factors Affecting Soil Wetness Indicators

Subsurface Site Hydrology As It Pertains
To Wastewater Treatment and Disposal in Virginia

Grant #NA870Z0253-01

", ~ Submitted by

Carl D. Peacock, Jr.
Jay F. Conta
Phillip R. Cobb
Gary F. Whitley

Prepared for

Virginia Department of Environmental Quality
Virginia Coastal Resources Management Program

National Oceanic and Atmospheric Administration
Office of Ocean and Coastal Resources Management

December 3,2001

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INTRODUCTION

Redoximorphic feature formation is directly influenced by climate, time, organisms, organic matter and saturation. Climate refers to both temperature and precipitation. Time is usually a measurement of years and centuries rather than hours and days. Organisms refer to both animals and vegetation and their interaction with soils. Organic matter is needed as food to fuel the microbial process. Saturation is needed to complete the anaerobic process.

Climate refers to both temperature and precipitation that occur at a given site. Virginia has the four traditional climatic seasons with winter being the coldest and wettest and summer being the hottest and driest in relation to air and soil temperatures, precipitation, and seasonal high water tables.

Time, in reference to soils, is not usually measured in hours and days but by years and centuries.

Organisms refer to both animals and vegetation and their interaction with soils. This interaction with soils takes minerals and recycles them back through living and dying processes and promotes soil development through structural alteration and accumulation.

Organic matter is needed as a food source for microbial activity.

Saturation is needed to complete the anaerobic process. This saturated condition also must be oxygen depleted in order for the reduction of iron to be maximized.

Although these factors of soil formation are usually considered in geological terms, we must consider them in monthly and daily terms to relate interpretation of soils to human land-use practices. Neither can we separate any of the factors from themselves because they are inter-related. We cannot separate landscape from seasonal high water tables and temperature, nor microbial activity, organic matter, and mineral oxidation from soil horizon colors. They are all intermingled and dependent on each other.

The Virginia Department of Health has been given the responsibility to determine suitability of drainfield sites by evaluating soils. The Department of Health's Sewage Handling and Disposal Regulations, revised July, 2000, have specific requirements that must be met in order to issue a wastewater treatment and disposal permit. The regulations state that "gray and/or gray mottlings indicate seaSonal water tables for at least three weeks duration". They also state that "red and yellow mottlings may indicate slow internal drainage and may indicate a seasonal water table". It is the "red and yellow mottlings" that are of issue in this research.

REVIEW OF LITEATURE

The relationship between soil mottling .and seasonal soil moisture has been recognized for many years (Soil Survey Staff, 1951, 1975, 1999). The mottled pattern of soil color is the result of the reduction and translocation of iron oxides. The grayer zones represent areas from which most of the iron oxides have been reduced and removed, and the presence of red mottles indicate areas where iron has accumulated and reoxidized.

Jenny (1961) suggested that "spots or grains (mottling)" represent that "at some time it (the soil) was subject to long continued submergence or at least to drenching with water."

Albrecht (1941) stated that the gray colors of subsoils could also be related to the presence of an anaerobic or saturated condition with microbial activity being responsible for the processes producing gray colors.

Simonson (1954) produced evidence that man-induced practices, such as lakes in Tennessee, can cause mottling and gleying in soils. The soils originally had red to yellowish-red subsoils with no mottles but were found to have duller colors with gray and yellow mottles after 10 years of fluctuating water levels on sloping areas. These mottles represented reduction and removal of iron oxides.

Simpson (1978) created soil mottles under laboratory conditions of chroma 3 or more, in previously unmottled soils in 3 months by saturation with secondarily treated municipal effluent and mottles of chroma 2 or less in six months. No mottles were formed in soil cores saturated with distilled water for the same period. Simpson concluded that apparent water tables occur above the depth to mottling in some soils and that soil mottling is an indicator of the minimum depth to the apparent water table for some extended time period that occurs while the soil temperature is warmer than 15 degrees C. Simpson also concluded that mottling was an indicator of the minimum depth to the apparent water table that occurred from early May until late November in Montgomery County, Pa.

Soil Taxonomy (Soil Survey Staff, 1975, 1999) accepts mottles with chroma 2 or less as an indication that the. horizon with such mottles is saturated with water at some period of the year.

Daniels et. al. (1971) found that pale brown (10YR 6/3) and very pale brown (10YR 7/3) mottling were prominent at depths saturated 25% of the time and gley colors developed at profile depths saturated more than 50% of the time.

Evans and Franzmier (1986) found that soils with no chromas less than or equal to 2 but with some three or four chroma colors had water-oXygen regimes of occasional saturation and oxidation. They found that soils with such color patterns were saturated (1) I to 20% of the time between 0.1 - 0.3 meters (4-12 inches), (2) 20 to 40% of the time between 0.3 - 0.6 meters (12-24 inches), and (3) less than 50% of the time between 1.0 - 1.5 meters (40-60 inches).

Daniels et. al. (1987) and Franzmeier et. al. (1983) suggest that soil mottling of chroma 2 or less represents the minimum depth to the apparent (seasonal) water table and that mottles having a chroma of 3 or less in a matrix of stronger or higher chroma were good. indicators that a horizon is saturated sometime during the year. Daniels et. al. (1987) concluded that these mottles are common in nearly level areas of the Coastal Plain and recommended that (1) Udults with "7/3, 6/3, or 5/3 mottles in a matrix with stronger (higher) chroma be considered gley mottles and (2) that soils having these mottles in the upper 75 cm. (30 in.) be placed in Aquic subgroups".

Organic matter and soil temperature also have a great impact on the soil matrix and mottling colors. Couto et. al. (1985) suggested that reduction does not occur in the field even when a high water table is present due to the lack of a source of energy for microbial activity. Couto inferred that organic matter present is too stable and/or too Iow in available nutrients for the reduction process to take place during the water logging pedod.

Latshaw and Thompson (1973) plotted both the depth to mottling and time periods when the soil temperature was below 15 degrees C. (59 degrees F.) on water table graphs. Differences were noted between depths to mottles and the apparent water table. The apparent water table was found to be .nearer the soil surface at time periods when soil temperature was less than 15 degrees C. This difference appears to be related to microbial inactivity at temperatures less than 15 degrees C. which represses the soil bacteria that induce mottling by reducing iron. Soil temperatures are lowest during the months of January through March and April, which corresponds to that pedod of time when seasonal water tables are closest to the surface.

Vepraskas and Wilding (1983) concluded that "in soils containing Iow (< 1.0%) levels of organic matter 'in horizons below the Al or Ap, seasonal saturation and reduction were found to occur in horizons having dominant color chromas of 3 or less along ped exteriors where mottled ped interiors had color chromas of 4 or more". Published reports indicate that at least 1% soil organic matter is needed to provide energy for the microbial process to reduce iron and create gray mottles.

Upon evaluating laboratory results from Soil Survey activities (both soil chemistry data from the Va. Tech Lab and Quick Test data from Blacksburg and Painter), it was determined that almost all horizons below the Ap or Al have less than 1% organic matter. Most had less than 0.5%. These data were taken from soil surveys conducted at various locations in Virginia's Coastal Plain.

CONCLUSIONS

Redoximorphic Features:

The literature references seasonal wetness duration as being greater than 25% of the time in soils with chroma 3 and 4 redoximorphic features. Our data supports this conclusion. Ackwater, Dogue and Munden soils have Bt hodzons with vadng degrees of redoximorphic features (mottles). Soils with chroma 3 and 4 mottles in the Bt horizon represented 20% seasonal wetness duration in Ackwater and Munden soils and 33-45% in the Dogue soils during the winter-spring period. However, the Emporia soil showed seasonal wetness for 65-84% of the time during the winter-spring period.

Chroma I and 2 mottles indicate wetness for at least 50% of the time according to the literature. Horizons with gray mottles in the Bt represented 30-35% seasonal wetness duration in Munden soils and 50-65% in the Ackwater and Dogue soils during the winter-spring period.

The Btg horizons in the Acredale, Dogue, Dragston, Kinston, Lenoir, and Yemassee soils had greater than 75% seasonal wetness duration during the winter-spring period. Nimmo soils did not have wetness for this duration due to adequate drainage.

Manganese features are not as definitive as chroma 2 or less mottles. Soils with manganese that are on'a poor or questionable landscape generally indicate periodic wetness and fluctuating water table. This was evident in the Cotaco soil.

Landscapes:

Landscape position can have a strong impact on the amount of groundwater any given site might have. The Spotsylvania-like and Faceville soils were similar to the two Emporia soils studied, but were located on a shoulder and sideslope position. They were dry during the entire study period. The Emporia soils, one on a lower sideslope and one on a broad upland landscape, had free water present for 3-4 months. Acredale, Dogue, Dragston, Lenoir and Yemassee soils were located on broad upland fiats, while the Kinston soil was located on a narrow floodplain.

Soils located on shoulder positions or on a narrow summit will be significantly drier than the same soil located on lower sideslopes or on broad (ie, lacking good surface drainage) landscape positions. Soils located on shoulder or narrow summit positions may have mottles that do not reflect current wetness characteristics. These sites may need a water table study to assess their true wetness potential.

Soils located in poor landscape positions (~e, lower sideslope, footslopes with a long upslope watershed and broad uplands lacking good surfai:e drainage) may be wetter than their mottling might indicate. One Emporia site and the Cotaco site had long upslope watersheds.

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